Silicon Valley
ITS West Corridor Project

CITY OF SAN JOSE
CAPITAL OF SILICON VALLEY

Concept of Operations
Final Report

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Section 1: Introduction

The purpose of this report is to establish the means and procedures for addressing technical and institutional issues related to the Silicon Valley Intelligent Transportation Systems (SV-ITS) West Corridor Project. Many of the technical issues covered are related to the system design such as location of field devices, communications alternatives, data and video exchange requirements, ITS architecture and standards, and system integration. Institutional issues that are addressed include Smart Corridor operation, preliminary control of field devices, operations and maintenance, and other aspects associated with the project.

The *Concept of Operations* defines the final project and identifies the technical and institutional actions that should be taken to achieve the desired system. The following issues will be investigated in this *Concept of Operations Report*:

- Roles and responsibilities of participating agencies;
- The existing or required agreements for operation of the resulting system;
- The resources (equipment, staffing, training) needed to operate and maintain the system;
- Evaluation of closed circuit television (CCTV) camera technologies, vehicle detection technologies and video transmission requirements;
- Location of field devices including CCTV cameras, vehicle detection systems, and emergency vehicle priority;
- Analysis of upgrades/revisions required to the existing communication network to accommodate the video and data transfer needs;
- Evaluation of the means for expanding the data exchange network communication infrastructure and the equipment requirements;
- Coordination with the SV-ITS program partners and related SV-ITS projects to ensure the effectiveness of the regional management plan; and
- Compliance with National ITS Architecture and Standards.

1.1 Project Overview

The intent of the SV-ITS West Corridor project is to install ITS field equipment along the project corridor as well as to install supporting hardware and software components at the San Jose Traffic Management Center (TMC) and Cupertino Traffic Operations Center (TOC) to enable center-to-field ("C2F") and center-to-center ("C2C") traffic signal system data and video exchange, and to enable shared system control between the SV-ITS partner agencies. The ITS field equipment to be deployed are primarily CCTV cameras and vehicle detection devices. The monitoring capabilities provided by the CCTV cameras will improve incident management and help alleviate traffic congestion along the highly congested Stevens Creek Boulevard corridor. The data received from the vehicle detection systems will be used to update traffic responsive timing patterns, which will be implemented as part of this project in the vicinity of the Westfield Shopping Center. A preliminary map of proposed field device locations for the Silicon Valley ITS West project is provided in Section 4.

Additionally, a fiber optic communications system will be designed and implemented to support the ITS field equipment installed for this project. The fiber optic communications system designed for this project will be integrated with the existing Silicon Valley Smart Corridor (SVSC) project system and the De Anza Boulevard Advanced Transportation Management System (ATMS) project to enhance regional functionality of the SV-ITS Program.

The SV-ITS West project is funded by grants from the Congestion Mitigation and Air Quality (CMAQ) Improvement Program and the State Transportation Improvement Program (STIP). The total amount of grant funding is $3,105,000.

1.2 Corridor Description

The SV-ITS West Corridor project encompasses six jurisdictions west of State Route (SR) 17. The project partners include Caltrans, Santa Clara County, and the Cities of Cupertino, Santa Clara, Campbell, and San Jose, the lead design agency. The principal arterials that will be receiving ITS improvements as part of this project are Stevens Creek Boulevard, Wolfe Road, Saratoga Avenue and Hamilton Avenue. However, Stevens Creek Boulevard is the primary project corridor and the focus of this project will be to improve interagency traffic operations along this corridor.

Stevens Creek Boulevard

Stevens Creek Boulevard is a six-lane principal arterial that stretches approximately eight miles west to east from SR 85 to I-880. Stevens Creek turns into San Carlos Street east of I-880. The arterial traverses through the cities of Cupertino, Santa Clara, and San Jose and is parallel to I-280, which is heavily congested in both directions during the a.m. and p.m. peak periods. According to Caltrans 2000 traffic counts, I-280 carries between 12,500 and 17,100 vehicles per hour (vph) during the peak hour and between 144,000 and 209,000 vehicles per day (vpd) near Stevens Creek Boulevard. The highest concentration of traffic on this section of I-280 is near Saratoga Avenue, especially the I-280 southbound on ramp from Saratoga Avenue and the I-280 northbound off ramp onto Saratoga Avenue. Near Saratoga Avenue, I-280 operates at level of service F in the northbound direction in the morning peak hour and level of service F in the southbound direction during the evening peak hour. The traffic volumes are projected to increase on I-280 between SR 17 and SR 85 due to the residential, commercial and industrial growth in the cities of San Jose, Cupertino, Sunnyvale, and Santa Clara.

As a result of the freeway congestion on I-280, drivers are using Stevens Creek Boulevard as a reliever route. According to 2000 City of Cupertino traffic counts, Stevens Creek Boulevard carries approximately 31,000 vpd in the City of Cupertino. Stevens Creek Boulevard is also a major bus route for the Santa Clara County Valley Transportation Authority (VTA). Currently, eight bus routes (23, 23A, 25, 36, 51, 53, 55, 81) and one express/super express route (101) travel along Stevens Creek Boulevard in the cities of Cupertino and San Jose. The routes that have the most riders per day are routes 23, 25, and 81. Stevens Creek Boulevard is also a major truck route and has bike lanes on both sides of the roadway. Along with heavy transit usage, large amounts of goods and services travel along Stevens Creek Boulevard due to regional shopping centers, auto dealers, corporate offices, and industrial uses located adjacent or in the vicinity of the corridor.

Several major regional shopping centers are also located on or near Stevens Creek Boulevard, including Vallco Fashion Park Mall, Westfield Shopping Center (formerly Valley Fair Mall), and Santana Row, a 42-acre commercial and residential project under development at the site of the former Town & Country Village shopping center. During the weekends and holiday season, these venues generate noticeable increases in traffic volume. For example, traffic heading towards Westfield Shopping Center queues up past the exit ramp on I-880 at Stevens Creek Boulevard onto the main lanes of I-280 during the holiday season. When Santana Row is opened, Stevens Creek Boulevard is expected to experience increased traffic volumes particularly on weekends and during the holiday season.

Levels of service for most of the key intersections in the project corridor are provided in **Table 1-1**. Notice that several intersections along Stevens Creek Boulevard already operate at a level of service (LOS) D or worse during both the morning and evening peak hours throughout the whole year. Stevens Creek Boulevard/Winchester Boulevard and Stevens Creek Boulevard/Saratoga Avenue operate at level of service D. Stevens Creek Boulevard/San Tomas Expressway operates at LOS F. Weekend and holiday mall traffic is also a concern to both the cities of Cupertino and San Jose at the intersections of Wolfe Road/Stevens Creek Boulevard and also Stevens Creek Boulevard/S. Monroe Street. Both intersections are entry points into Vallco Fashion Park Mall and Westfield Shopping Center, respectively

Another high trip generator on Stevens Creek Boulevard is the Flint Center located at De Anza College in Cupertino. When there are events at the Flint Center, traffic enters and exits off of Parkwood Boulevard and Stevens Creek Boulevard. This affects the progression of traffic on Stevens Creek Boulevard due to the high volume of side street event traffic from the Flint Center.

Table 1-1: 2001 Levels of Service

Intersection	Jurisdiction	Level of Service
Stevens Creek @ Rt. 85 South	Cupertino	C
Stevens Creek @ Rt. 85 North	Cupertino	C
Stevens Creek @ Stelling	Cupertino	D
Stevens Creek @ Blaney	Cupertino	C
Stevens Creek @ Wolfe	Cupertino	D
Wolfe @ Homestead	Cupertino	D
Wolfe @ 280 North	Cupertino	C
Wolfe @ 280 South	Cupertino	B
Stevens Creek @ I-280	Caltrans	C
Stevens Creek @ Lawrence Expwy.	Santa Clara	D
Stevens Creek @ Saratoga	San Jose	D
I-280 @ Saratoga North	San Jose	B
I-280 @ Saratoga South	San Jose	D
Stevens Creek @ San Tomas Expwy.	SC County	F
San Tomas Expwy. @ Saratoga	SC County	F
Stevens Creek @ Winchester	San Jose	D
Hamilton @ Winchester	Campbell	D

Wolfe Road

Another principal arterial in the project area is Wolfe Road from Stevens Creek Boulevard to Homestead Road in Cupertino. According to 2000 City of Cupertino traffic counts, Wolfe Road carries approximately 29,000 vpd south of I-280 and nearly 41,000 vpd north of I-280. This section of Wolfe Road is a six-lane divided principal arterial. It is a major truck route and will have bike lanes on both sides of the road. Currently, there are three local VTA bus routes (36, 51, and 81) and one express/super express VTA route (101) on Wolfe Road.

A high amount of traffic is due to the retail centers on Wolfe Road and corporate offices north of I-280. Wolfe Road is the main entryway into the Vallco Fashion Park Mall, which is located on both sides of Wolfe Road from I-280 to Stevens Creek Boulevard. As a result, heavy goods and service vehicles use Wolfe Road to deliver freight to the retail center. There is another retail center north of Vallco Fashion Park Mall on Wolfe Road called Cupertino Village. Also, Hewlett Packard has a corporate office at the southeast corner of Homestead Road and Wolfe Road.

It is also important to point out that Wolfe Road serves as a major transition point between I-280 and Stevens Creek Boulevard. When I-280 gets congested, motorists use Wolfe Road to cut over to Stevens Creek Boulevard, which they use as an alternate route to I-280.

Saratoga Avenue

Another arterial in the project area is Saratoga Avenue between I-280 and the San Tomas Expressway. This section of Saratoga is a 6-lane arterial. Saratoga Avenue experiences heavy traffic at the I-280 interchanges. As with Wolfe Road, Saratoga Avenue is highly congested in the project area and it serves as a major transition point between I-280 to Stevens Creek Boulevard. When I-280 gets congested, motorists use Saratoga Avenue and Kiely Boulevard to cut over to Stevens Creek Boulevard for an alternate east-west route. In particular, the Saratoga Avenue/Kiely Boulveard intersection experiences heavy congestion.

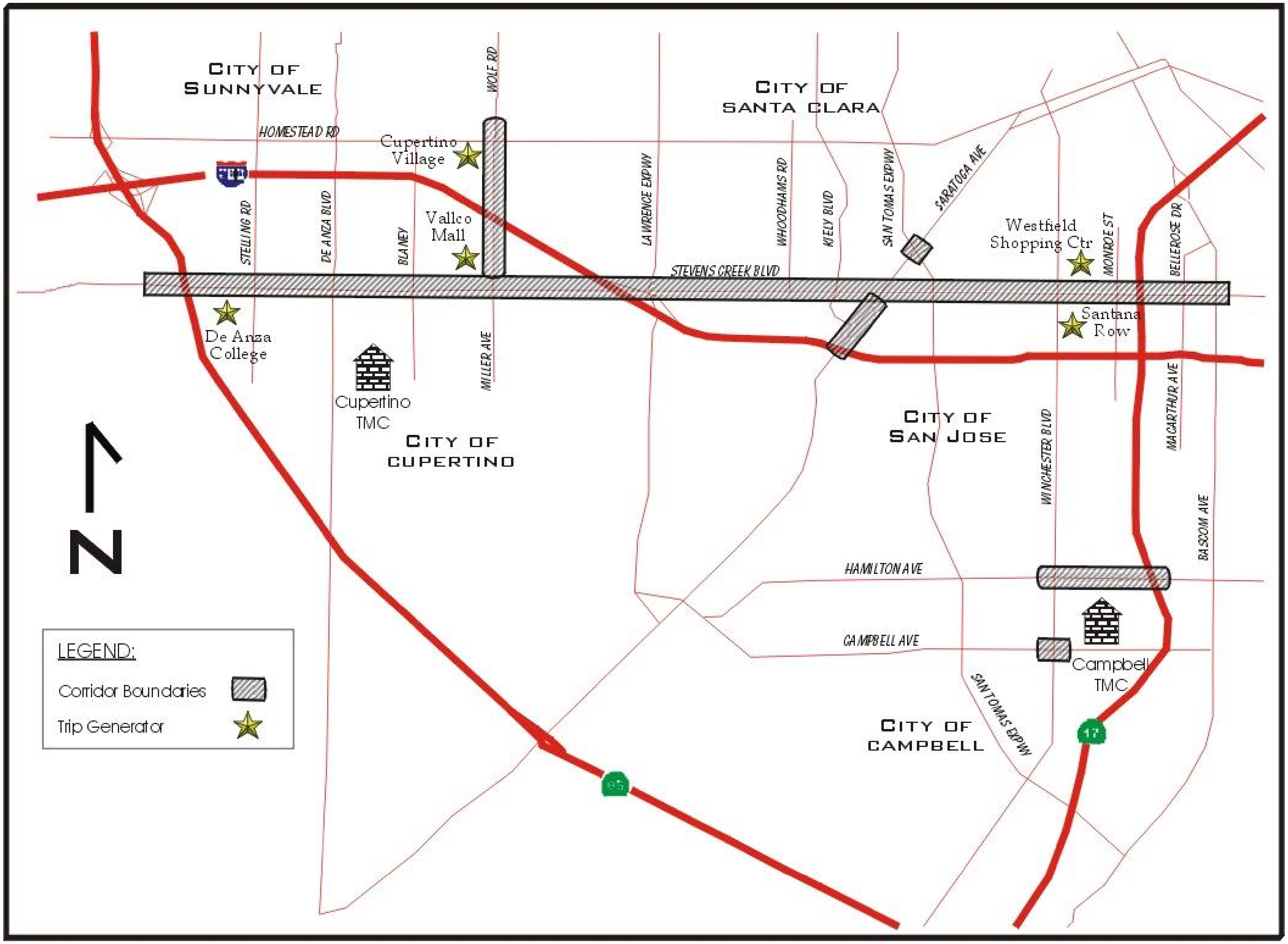
Hamilton Avenue

The final arterial in the project area is Hamilton Avenue between SR 17 and Winchester Boulevard. Hamilton Avenue runs parallel to Stevens Creek Boulevard to the south. This section of Hamilton Avenue is a 6-lane arterial with signalized intersections at Winchester Boulevard and Central Avenue. These two intersections currently have video detection systems installed that can be used for monitoring purposes if the video is brought back to the Campbell TMC on the fiber being installed for the project. A previous SVSC project had installed a fiber link on Hamilton Avenue between Salmar Avenue and Bascom Avenue to connect the Campbell TMC to the SV-ITS network. This project will extend the fiber link on Hamilton Avenue from Salmar Avenue to Winchester Boulevard. If the existing video detection systems along Hamilton Avenue are upgraded to have surveillance capabilities at this time, the improvement will not directly benefit interagency traffic management efforts along Stevens Creek Boulevard.

Figure 1-1 shows the extents of the Silicon Valley ITS West project corridor project.

Although this section along Hamilton Avenue is not directly tied in to the Stevens Creek Boulevard trunk fiber, the surveillance capabilities on Hamilton Avenue extends the existing system from Bascom Avenue further into Campbell, with communications back to the Campbell TMC via fiber on Bascom Avenue.

FIGURE 1-1: Silicon Valley ITS West Corridor Boundaries



1.3 Project Goals

The goals of the SV-ITS West project will be consistent with the goals of the SV-ITS program. The SV-ITS program is a partnership between the Cities of Cupertino, San Jose, Campbell, Santa Clara, Los Gatos, Milpitas, Fremont, Santa Clara County, Caltrans, Santa Clara Valley Transportation Authority (VTA), Metropolitan Transportation Commission (MTC), and California Highway Catrol (CHP) to provide a regional transportation management system. The SV-ITS West Corridor goals include:

- Provide partner agencies with the ability to perform coordinated traffic signal timing across jurisdictional boundaries, including traffic responsive signal timing;
- Provide partner agencies with the ability to actively manage traffic diverting from the freeway to minimize impacts on surface streets;
- Provide partner agencies with the ability to rapidly respond to and clear incidents on both freeway and surface streets;
- Enable partner agencies to reduce traffic-related delays caused by incidents on both freeway and surface streets;
- Improve partner agencies' ability to collect and disseminate up-to-date travel condition information for the TMC staff and the public; and
- Permit the continued sharing of resources between partner agencies whenever possible.

Aside from the goals mentioned above, another key goal of this project is to better manage congestion along Stevens Creek Boulevard in a multi-jurisdictional environment by sharing information and resources between agencies. In order to achieve this, it is necessary to meet the goals of local and regional traffic management. Local goals focus on improving traffic flows for local traffic, monitoring local roadway conditions and minimizing impacts of regional congestion on local streets. Regional goals focus on improving traffic flows between adjacent jurisdictions through the development and implementation of coordinated traffic signal timing plans with emphasis on managing traffic congestion in the Westfield Shopping Center area. Also, regional goals focus on ensuring compatibility between ITS elements, including both equipment and communications protocols to enable sharing of data and video between agencies.

1.4 Functional Requirements

In order to achieve the above stated project goals, the following functional requirements must be met as part of the SV-ITS West project.

- *Provide video monitoring capability* on Stevens Creek Boulevard, Wolfe Road, Saratoga Avenue and Hamilton Avenue at key intersections.
- *Provide traffic monitoring capability* on Stevens Creek Boulevard near Westfield Shopping Center using system detector loops.

- *Implement traffic responsive signal timing plans* on Stevens Creek Boulevard in the Westfield Shopping Center vicinity to address weekend and holiday mall traffic.
- *Provide emergency vehicle preemption* at Stevens Creek Boulevard and Monroe Avenue to facilitate safe emergency egress for fire personnel from a fire station located south of the intersection and improve safety and emergency response time of emergency vehicles.
- *Provide field-to-center communications* to allow TMC personnel in San Jose, Cupertino, Santa Clara and Campbell to access data and video collected from the ITS field devices.
- *Provide center-to-center communications* between Cupertino TMC and San Jose TMC to enable video and data sharing and coordinated traffic signal timing along Stevens Creek Boulevard.
- *Enhance the Silicon Valley Smart Corridor Fiber network* by installing new fiber infrastructure along Stevens Creek Boulevard, Wolfe Road, Saratoga Avenue and Hamilton Avenue and tying the new fiber infrastructure along Stevens Creek Boulevard into existing SV-ITS fiber infrastructure at Bascom Avenue and the Cupertino De Anza Boulevard fiber infrastructure at De Anza Boulevard.

1.5 Related Projects

There are several joint federal and locally-funded projects on Stevens Creek Boulevard that are currently under design to alleviate some of the congestion in Cupertino on Stevens Creek Boulevard. The design of the De Anza Advanced Traffic Management System (ATMS) project was recently completed and is expected to go out to bid this fall. The De Anza ATMS involves installing eleven CCTV cameras along De Anza Boulevard as well as a fiber optic communications system to bring the video from the cameras to the City of Cupertino TMC. In addition, the fiber will be used for traffic signal interconnect to transmit data between the existing traffic signals on De Anza and the Cupertino TMC. The De Anza ATMS fiber and CCTV camera system will be utilized by the SV-ITS West project to achieve the project goals.

The City of Cupertino Adaptive Traffic Signal project involves adding adaptive traffic control functionality to the central traffic management system and all 50 traffic signals in the City of Cupertino. Algorithms will be developed to estimate traffic volume from existing occupancy detectors for real-time applications and traffic modeling. This project will build on the Generation 1.5 signal timing project which was implemented in 2001. The traffic adaptive project, scheduled to be implemented by the end of 2002, will not impact the SV-ITS West project.

The Santa Clara County Traffic Operations System (TOS) project involves the installation of CCTV cameras, vehicle detectors and fiber optics communications along nine expressway corridors in Santa Clara County. Each of the nine expressway corridors is treated as a separate project. Some of these projects will impact the SV-ITS West project. The Lawrence Expressway project, which has recently gone out to bid, includes the installation of a CCTV camera at Stevens Creek and Lawrence Expressway. Also, the Foothill Expressway project, which is in the design phase, includes the installation of fiber along Stevens Creek Boulevard from Foothill Boulevard to Peninsula Avenue. The SV-ITS West project will tie into the TOS fiber at Peninsula Avenue and provide the County with additional fiber coverage.

The City of San Jose has two related projects that are ongoing. The Smart Intersections project involves interconnection of 100 traffic signals, installation of related infrastructure and necessary services to support signal system coordination, traffic management, traffic responsive signal timing, equipment status monitoring, and incident detection. None of the Smart Intersections are part of the SV-ITS West project; however, the project includes spread spectrum radio along a mile stretch of Winchester Boulevard south of I-280. If the SV-ITS West Corridor ever expanded to this area, the Smart Corridor could utilize the infrastructure being installed with the Smart Intersections project.

The San Jose Pro-Active Signal Timing Project involves developing signal timing plans for over 500 intersections in San Jose. The new timing plans are scheduled to be implemented next spring. Many intersections along the Stevens Creek Corridor will be implementing new timing plans as part of the Signal Timing project but this should not affect the SV-ITS West project. Some of these intersections will be enhanced with traffic responsive timing plans after the construction of the SV-ITS West project. The traffic responsive timing plans will most likely be introduced in the summer of 2003.

Section 2: Technical Requirements and Alternatives

As mentioned previously, the Concept of Operations Report identifies the technical and institutional actions that should be taken to achieve the desired goals of the project. This section describes the existing SV-ITS systems and then addresses the technical requirements for this project including communications, CCTV cameras, detection systems and TMC enhancements. Since the technical requirements and alternatives are covered in detail in the *Design Requirements Report*, they are only briefly introduced in this report.

2.1 Existing Systems

City of San Jose

The City of San Jose currently controls approximately 552 of its 812 traffic signals from a TMC located at the Department of Transportation offices in Downtown San Jose. All of the City-operated signals on Stevens Creek Boulevard within the project area are currently interconnected to the TMC via leased telephone lines. The City has expressed a desire to upgrade the existing signal interconnect from leased telephone lines to fiber optics as part of this project.

The existing San Jose TMC currently uses the Transcore (formerly JHK & Associates) Series 2000 central traffic management system (TMS) to manage its traffic signal infrastructure. The system has been in operation since 1991. Currently, 552 signalized intersections in the City of San Jose are connected to the Series 2000 system and are often referred to as “smart intersections.” The Series 2000 software runs under the Windows operating system with Digital Electronic Corporation (DEC) server hardware. Additionally, the San Jose TMC includes numerous workstations, video monitors, video control and switching equipment and racks filled with communications equipment.

The Series 2000 system communicates to the local controller via two pair, twisted wire or dedicated leased phone line communication channels. There are currently 119 communications channels for the traffic signal controllers. Each communication channel includes two to seven controllers. There are a total of 143 channels with 24 spares. The current system communicates to the local controller via Simple Network Management Protocol (SNMP) format at 1200-baud data rate.

In addition to the twisted pair and leased phone lines, the City also utilizes a microwave link for the Coleman Avenue corridor; a spread-spectrum link for the Berryessa corridor; and a fiber channel for the Bascom corridor, connected to the County intersections.

The Series 2000 system is also integrated with the City's CMS and closed-circuit television (CCTV), to provide an Integrated Workstation. The integrated workstation is used for event management applications. Series 2000 also is linked to other systems for incident/event management including the SVSC data exchange network (DEN).

City of Cupertino

The City of Cupertino currently controls approximately 40 of its 54 traffic signals from a TMC located in City Hall on Torre Avenue. All of the signals on Stevens Creek Boulevard and Wolfe Road within the project corridor are interconnected to the TMC via copper twisted-wire pairs (TWP). The City has expressed a desire to upgrade the existing signal interconnect from TWP to fiber optics as part of this project.

The existing Cupertino TMC contains a central signal system server and workstations, two CCTV monitors, one large screen monitor, one videocassette recorder (VCR) and communications equipment. The server and workstations are equipped with the Naztec Streetwise software, a traffic management system (TMS) which enables TMC operators to control traffic signals remotely. Cupertino's TMS does not currently have an interface with the DEN but one will be added as part of this project.

The following equipment will be added to the Cupertino TMC as part of the De Anza ATMS project: video matrix bay, video CPU/controller, fiber distribution center, eleven (11) video optical transceivers (VOTR), two optical transceivers (OTR), a code distribution unit, and a video multiplexer. This equipment should be existing when the SV-ITS West project is constructed.

City of Campbell

The City of Campbell currently controls 34 of its 38 traffic signals from a TMC located in City Hall on Campbell Avenue. The signals are interconnected to the TMC via TWP. The City of Campbell has fiber installed on Campbell Avenue from the TMC east to Bascom Avenue, then north on Bascom Avenue to Hamilton Avenue, then west to Salmar Avenue. The City also has fiber that runs from City Hall west on Civic Center Drive to the Campbell Community Center. The City of Campbell has video detection installed at ten of their intersections on Hamilton Avenue and they are currently bringing video into their TMC from three of them. The City is using its existing fiber and SV-ITS fiber along Bascom Avenue to bring the video back to the TMC.

The Campbell TMC includes a central signal system and workstations, four video monitors, video control and switching equipment and a rack filled with communications equipment. One of the central signal systems is an ICONS system, which controls **xx** traffic signals that are part of the Smart Corridor. The City also uses the **xxx** central system to control **xx** traffic signals. Only the ICONS system currently has an interface with the DEN.

City of Santa Clara

The City of Santa Clara currently controls 109 of their 117 traffic signals from a TMC located in City Hall on Lincoln Street. The signals are interconnected to the TMC via

TWP. The City of Santa Clara has video detection cameras installed at 15 of their intersections and they are currently bringing video into their TMC from all of them.

The Santa Clara TMC includes two central signal systems, workstations, 11 video monitors, video control and switching equipment and a rack filled with communications equipment. The ICONS central signal system controls four traffic signals on De La Cruz Boulevard as part of the Smart Corridor. The Traconex signal system controls the other 105 traffic signals by way of the six master controller systems. Only the ICONS system currently has an interface with the DEN; however, the City has experienced problems with this interface. Santa Clara is currently in the process of developing a long-range ITS plan where they are considering upgrading to a different TMS in the near future. The future TMS, which would include a DEN interface, is not likely to come online for at least a year or two. Santa Clara is currently linked to the County TMC.

County of Santa Clara

The County of Santa Clara has jurisdiction over two County Expressways in the project area. They are the Lawrence Expressway and San Tomas Expressway. As part of the TOS project, the County is in the process of implementing ITS elements such as CCTV cameras, changeable message signs (CMS) and a supporting fiber optics communications system along these corridors. The County also has a TMC with a central signal system and workstations, a DEN server and CWD workstation, video switching and control equipment, video monitors, and equipment racks. The County's central signal system, a Naztec Streetwise system, interfaces with the DEN. The County TMC is currently linked to the City of Santa Clara TMC, San Jose TMC and other SV-ITS TMCs.

Caltrans

Caltrans is generally responsible for freeway management in the Bay Area. To support this mission, they employ a number of ITS technologies on the freeways including CCTV cameras, vehicle detectors, CMS, highway advisory radio, and ramp meters. All of these ITS elements are controlled from the District 4 TMC located in Oakland. The TMC houses 19 operator consoles, a large video wall, equipment rooms, a computer room, an emergency management room and the TravInfo traveler information center. Besides Caltrans staff, representatives from the California Highway Patrol and TravInfo are also present in the TMC.

There is one existing Caltrans owned CCTV camera in the project corridor. In addition, seven new CCTV cameras will be installed in Caltrans right of way. All of these cameras will be designed according to State standards and fed back to the District 4 TMC via ISDN or DSL. Currently, all cameras on Bay Area freeways are manufactured by Cohu and mounted on a dedicated pole. Each camera has a Cohu camera control unit housed in a Model 334 cabinet adjacent to the camera pole. PTZ control communications with these cameras use a protocol unique to Caltrans District 4. Most cabinets also contain an Enerdyne Motion encoder to digitize the video stream for communication to the TMC. Equipment is powered by the connection to the local 120 VAC main power.

Data Exchange Network (DEN)

The DEN allows the users to subscribe to data from devices belonging to the participating SV-ITS program agencies via a Wide Area Network (WAN). The DEN provides a means of transmitting real-time data between the transportation management system (TMS) employed by the agencies. The real-time data include traffic counts, facility status, incident information, equipment status, planned events, and operating changes.

Since the development of the software started prior to the adoption of standards for data exchange nationally, the DEN currently is based on the "sockets" portion of the NTCIP center-to-center protocol only. All data communications between the TMCs occur at the DEN server. The DEN server, in turn, requests the data from the local TMS. Data to be displayed on the corridor wide display (CWD) is sent from the DEN to the CWD system. The client user interface, which manages the subscription functions, is resident in the workstation.

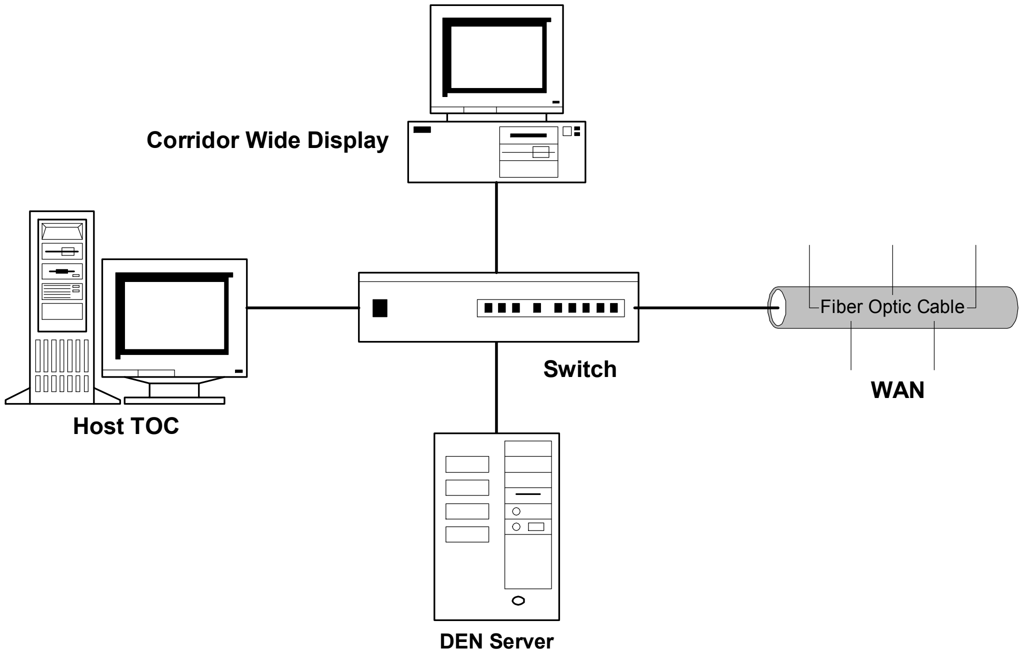
Interfaces have been developed between IBI's DEN server and a number of SV-ITS traffic management systems already. DEN interfaces currently exist for the following TMSs: Transcore Series 2000 at City of San Jose, Gardner Systems ICONS at the City of Santa Clara and the City of Campbell and the Naztec Streetwise system at the County of Santa Clara. A DEN interface will be developed for the Cupertino Naztec system as part of the SV-ITS West project.

The DEN network allows basic commands, as well as data, to be sent between agency systems. For example, for traffic responsive operations, it will allow detector data collection as well as selection of timing patterns for implementation of a common timing plan across jurisdictional boundaries.

The DEN system manages subscriptions, security (such as user log-in and passwords) configuration of what data are to be offered to other agencies, monitoring of the data status, and transmission of data upon the occurrence of triggering events defined in subscriptions. All transmissions go to or from the DEN system. There are no direct communications between other elements of the TMC. **Figure 2-1** shows the physical layout of the DEN system at typical agency sites.

A more detailed description of the DEN and CWD design requirements and the SV-ITS data and video sharing architecture is provided in the *Design Requirements Report*.

Figure 2-1: DEN Network Configuration



The following are some elements of the existing SV-ITS DEN system:

- Each TMS has DEN software;
- The DEN software is identical in all TMSs;
- Each TMS has its own independent database, and there are no central, distributed or synchronized databases;
- All TMSs are connected to a common data communication network;
- The data exchanges include predefined data elements, with all TMSs using the same data formats and definitions;
- The TMSs communicate on a peer-to-peer basis, and there is no master or primary station;
- Data transmissions are generally event driven not request-and-reply. Subscribed data is transmitted continuously;
- Each TMS uses subscriptions to inform other TMSs which data it wants to receive;
- Subscriptions specify the data to send and the events that should trigger a data transmission
- Transmitted data can include commands;
- All transmitted data are real-time and only the current value is stored and available for transmission; and
- Agencies can create separate historical databases (elsewhere) and exchange by e-mail or other means.

The TMS manages various ATMS entities or components. The following are the devices or elements developed for data exchange capabilities:

- Traffic Signal Control Systems;
- Incident Information;
- CMS/EMS Systems;
- Ramp Meters;
- Detector Systems;
- HAR Status (future); and
- CCTV Status (future).

The subscription data are sent between nodes in accordance with subscriptions. Subscriptions are standing orders for sending data when pre-defined events trigger the occurrence. A password prevents unauthorized users to establish or change subscriptions for other nodes.

The Data Exchange system is a vital element for operation of a coordination transportation management system. This software is an excellent example for multi-agency cooperation and data exchange between the various disparate systems.

As part of the SV-ITS Enhancement project, IBI group will be upgrading the DEN software to full NTCIP standards using the DATEX portion of the center-to-center standards. This enhanced DEN software will be implemented for the SV-ITS West project.

2.2 Communications

At the beginning of this project, four communications alternatives were evaluated for the transmission of data and video between the field devices and the TMCs. These alternatives include copper twisted wire pair (TWP), fiber optics, microwave and telecommunications service providers.

The SV-ITS West Corridor project partners selected fiber optics as the communications medium to transmit data for C2F and C2C communications. One of the main reasons for the project partners choosing fiber, besides its high bandwidth, was that fiber optics are already being installed throughout much of Santa Clara County including Cupertino, San Jose, Campbell and City of Santa Clara. Thus, once the SV-ITS West project has been completed and integrated with the existing system, it will greatly enhance the SV-ITS fiber optic network.

2.3 CCTV Requirements

CCTV cameras will be installed at key intersections on the SV-ITS West corridor to allow real-time monitoring of traffic conditions. Video surveillance via CCTV cameras consists of cameras mounted on poles or mast arms that are remotely viewed and are mounted in a fixed position or with remotely controlled pan, tilt, and zoom (PTZ) capabilities. PTZ cameras will be installed for the SV-ITS West project in order to maintain consistency with related SV-ITS projects. CCTV technology and alternatives are discussed in greater detail in the *Design Requirements Report.*

CCTV cameras are typically installed at key locations where there is a potential of congestion related problems because of disruptive incidents, recurring high traffic volumes, or special events. Cameras can either be owned, operated, and viewed by one agency; can be owned by one agency but operated by multiple agencies; or a combination of both. Shared viewing is fairly easy to provide if the communications backbone is in place. Shared operation of cameras requires either an Internet Protocol addressing standard or sharing and integration of control protocols of differing video systems.

The CCTV cameras installed on the SV-ITS West project will be used to effectively monitor day-to-day traffic congestion and verify incident conditions along the project corridor. The primary goal is to monitor traffic along Stevens Creek Boulevard, particularly in the vicinity of the Westfield and Santana Row shopping centers and at freeway on ramps onto Stevens Creek Boulevard. The CCTV network design considers traffic monitoring capabilities at both the intersection level and corridor-overview level. The intersection level monitoring provides a clear view of all approaches at intersections where cameras are installed. The corridor-overview level monitoring provides a broad "bird's eye" view of traffic conditions along the project's major arterials and area highways.

Another technical requirement for the SV-ITS West project is that the CCTV cameras are compatible with those of the De Anza ATMS and other SV-ITS projects. This will allow the partner agencies' cameras to be viewed and controlled from their TMCs regardless of jurisdiction. In most cases, the partner agencies will be able to view up to four CCTV cameras at a time in their TMC.

All SV-ITS projects have all adopted Pelco CPU/Control systems and video matrix switches. These systems are interconnected in a network whose hub is located in the San Jose TMC. A Pelco network interface unit serves as the hub. For the SV-ITS West project, all PTZ cameras installed in the project area will be viewable by all of the partner agencies with a connection to the hub. Partner agencies will also have the ability to control these PTZ cameras depending on how the system is programmed. According to the most recent reconfiguration of the SV-ITS network, the following partner agencies will have a connection to the Pelco hub:

- City of San Jose;
- City of Cupertino;
- City of Campbell;
- County of Santa Clara;
- City of Freemont;
- City of Milpitas; and
- San Jose Airport.

In addition to the PTZ cameras, some existing video image detection cameras located in Campbell will be used for monitoring purposes. These cameras are capable of supplying presence, speed, volume, and occupancy data per lane to a traffic signal controller. Traditionally they have been used to help manage traffic incidents, congestion on roadways, vehicle identification, intersection monitoring, and signal actuation. For this project, existing video detection equipment will be linked via fiber to the Campbell TMC so that they may use the images for traffic monitoring.

The recommended CCTV locations and types of cameras to be installed at these locations are provided in Section 4.

2.4 Vehicle Detection Requirements

A primary purpose of vehicle detection systems is to detect an unforeseen reduction in arterial capacity or an inefficient use of signal time allocation. The detectors provide input to a process that initiates the appropriate procedures to restore the arterial streets to full capacity.

Detection of presence, volume and speed most commonly has been accomplished by using in-pavement inductive loops. In recent years there has been considerable testing of non-intrusive (overhead and sidefire) mounted detectors. Several detector technologies have emerged from these projects as being good candidates for detection at both intersections and freeway implementations. These technologies, which include Radar Detection, Laser Detection, Video Image Detection Sensors (VIDS), and Microwave Sensors are discussed in greater detail in the *Design Requirements Report*. Inductive loops are recommended for vehicle detection for this project since they are a proven technology and they are consistent with existing vehicle detection technologies being used by partner agencies in the project area.

Inductive loops can be installed at mid-block locations to act as system detectors. System detectors are used to calculate volume, occupancy and speed. The detectors are typically located 500 feet downstream from a signalized intersection. One loop is placed in each lane to count volume and occupancy, and to estimate speed. The loop detector data is then run back to the upstream controller cabinet.

Two locations on Stevens Creek Boulevard between Bascom Avenue and Winchester Avenue will have system detectors installed to feed real-time counts to the San Jose TMC. The loops will be installed in both the eastbound and westbound lanes at both locations. Traffic responsive signal timing patterns will be implemented as part of this project for the traffic signals on Stevens Creek Boulevard near the entrance to Town and Country Mall and Valley Fair Mall to help with the highly variable traffic volumes entering and exiting those sites. The traffic responsive timing patterns will change based on the data received from the new system detectors.

The recommended system detector locations are provided in Section 4.

2.5 Emergency Vehicle Preemption

The goal of an emergency vehicle preemption system is to allow the emergency service providers (fire departments and ambulances) to respond faster to the incidents, saving lives and minimizing congestion. Emergency preemption system includes the transmitter and detection units on emergency response vehicles and traffic signals to request and authorize priority treatment for emergency vehicles. The traffic signal will provide a priority in the direction of the emergency vehicle when a request has been validated.

This project will install emergency vehicle preemption at one location as further described in Section 4.

2.6 TMC Requirements

The TMC for each partner agency houses the computing equipment, software systems, communication end equipment, video switching and control equipment, and video monitors that help convey data and status information from the SV-ITS field equipment to, from, and between the various partner agency TMCs. The partner agency TMCs range in size, some consisting of a single desktop personal computer in a small office and others consisting of multiple workstations for numerous staff in a designated traffic control room.

A requirement of this project is to provide additional equipment and functionality to the City of Cupertino TMC to provide a two-way communications link between the Cupertino TMS and the SV-ITS Partner Agencies' TMS via the data exchange network (DEN) and corridor wide display (CWD) systems. The DEN enables coordinated and remote operation or monitoring of different agencies' TMSs. The DEN software required for activating traffic responsive pattern selection and incident timing plans and displaying signal status will need to be installed in Cupertino or integrated into their existing TMS as part of this project. Also, additional video and communications equipment will be placed in the Cupertino TMC. The agencies will agree on procedures for coordinated operation of their TMSs, as they deem necessary.

Many upgrades were made to the Cupertino TMC as part of the De Anza ATMS project but other physical upgrades will need to occur in the Cupertino TMC as part of the SV-ITS West project. These include:

- Enhanced DEN server;
- Enhanced CWD workstation;
- Software upgrade to Cupertino TMS to enable DEN interface;
- Communications equipment (video optical transceivers, multiplexers, Ethernet transceivers);
- Rack chassis to house the communications equipment; and
- Pelco code distribution unit for controlling PTZ cameras from the TMC.

In addition to the upgrades to the Cupertino TMC, there need to be some minor upgrades to the Campbell TMC and San Jose TMC as part of this project. These upgrades include the addition of multiplexers and an Ethernet transceiver in the Campbell TMC and the addition and reconfiguration of multiplexers, an Ethernet transceiver and an optical transceiver (OTR) in the San Jose TMC.

2.7 System Integration and Testing

In addition to the TMC equipment required for this project, software will be provided for Cupertino's DEN server and CWD computer workstation. This software is required to enable the following functionality:

- Bi-directional communications between the Cupertino central TMS (Naztec Streetwise) and the SV-ITS Program DEN and CWD systems,
- Uniform translation and formatting of Cupertino's TMS data for display on the CWD graphical user interface, and
- Shared signal systems control functions and data exchange between Cupertino TMC and partner agencies' TMC.

The DEN and CWD software installed for this project will be the same as the enhanced version planned for implementation with the SV-ITS Enhancement Project. The DEN and CWD software will need to be interfaced with the Cupertino TMS.

Upon completion of the DEN and CWD integration with the Naztec Streetwise central TMS at the Cupertino TMC, there will be end-to-end testing of the DEN and CWD systems to confirm that full two-way communications and data exchange capabilities exists between the Cupertino TMC and each individual partner agencies' TMC.

2.8 Fiber Requirements

Although fiber is more difficult to work with than copper during initial installation, the maintenance required with fiber is usually less during the life of the system. A disadvantage of fiber is that there will be a significantly higher up front cost for maintenance equipment. If the City decides to maintain the fiber themselves, there will be special maintenance equipment required such as an optical time domain reflectrometer (OTDR), fusion splicers and fiber cleavers, and there may be special training required for staff who may be unfamiliar with fiber maintenance.

Once the system is in place, fiber requires limited maintenance. The only exception is when fiber conduit is hit during construction activities. This risk can be minimized a number of ways. If the fiber is to be installed in new conduit then the conduit can be installed deep enough to minimize construction impacts. Also, the conduit can be encased in a concrete slurry, which makes it less susceptible to breakage than PVC. In addition, above ground warning tape should always be used to warn of underground fiber.

If the fiber is to be installed in existing conduit then other measures can be taken to ensure that construction risks are minimized. First, the conduit location can be marked using above ground markers or special fiber markers. One example of an above ground fiber marker is the das Curb Marker by das Manufacturing, Inc. This marker is a 4-inch diameter, orange sticker that adheres to pavement and can be used to indicate the location of buried fiber optics.

Second, trace wire can be installed in the conduit in the form of a bare copper wire or integrated into a pull tape. This will allow tracers to detect the exact location of the conduit from above ground when an electrical current is sent through the conduit. Finally, good as-built drawings can be kept on record and used to mark utility locations in response to an underground utility service alerts (USA).

Section 3: Operating Approach

This section describes how the overall system will be used, operated, and maintained by the project partners once it is constructed. A number of different issues are addressed such as roles and responsibilities of different agencies, data and video sharing policies inter-jurisdictional signal timing plan implementation policies, operations and maintenance, and institutional issues pertaining to agreement and other policy development.

3.1 Roles and Responsibilities

For the SV- ITS West project, the City of San Jose is the lead for overseeing design of the system and the County of Santa Clara is the lead for managing construction of the system. In addition, these two agencies will be the lead with respect to managing regional incidents. For incidents occurring on Expressways, the County will take the lead and for incidents occurring on Stevens Creek Boulevard, San Jose will take the lead. After detecting an incident, these agencies shall contact the other impacted agencies and follow procedures laid out in the *Incident Management Plan*.

Caltrans is ultimately responsible for freeway operations; however, they should also notify local agencies when there is a freeway incident in the project area that may impact local arterials. This is especially important if Caltrans plans too divert traffic off of the freeway onto local arterials. Caltrans shall also coordinate with local agencies on ramp metering plans in the project area to minimize the impact on arterials.

All of the partner agencies will be responsible for operating and maintaining their respective systems in a cooperative manner. This includes providing the fiscal resources necessary to fund these activities. Specific tasks related to operations and maintenance of the system are covered some in the following sections and in more detail in the *Operations and Maintenance Plan*.

3.2 Video Use and Sharing

For the SV-ITS West project, CCTV cameras will be used for traffic management related purposes only. They will be used to view and monitor traffic conditions along the project arterials and to monitor impacts of freeway traffic diverting to the local arterials during normal and incident conditions. CCTV cameras in this project are not intended for other uses such as police surveillance or red light running enforcement.

CCTV cameras can be used by staff located in a TMC to better manage traffic in real time. For instance, once TMC staff becomes aware of changes in traffic conditions or major incidents on an arterial, they can adjust the signal timing to improve level of service on that arterial. They could also dispatch crews to the scene of the incident to help clear the incident of necessary.

Each owning agency will be able to control CCTV cameras in their jurisdiction. CCTV control includes the view angle, degree of tilt, and zoom. If the owning agency chooses, other partner agencies may be permitted to control a camera when it is not in use by the owning agency. It is possible that these agencies could only move the cameras to pre-set views or the owning agency could be given first priority for control of their cameras. These control procedures and presets can be programmed into the central CCTV system. For this project, each partner agency will have full control of all CCTVs in the project area except those located in Caltrans right of way.

For cameras located in Caltrans right of way, Caltrans will have priority and local agencies will be limited to preset views. If a Caltrans camera is not in use by Caltrans, local agencies will have the ability to move the camera to one of the preset views but if the camera is in use by Caltrans, local agencies will not have the ability to view anything on the camera. There is currently one existing and seven proposed Caltrans cameras within the project corridor and Caltrans has expressed a willingness to share access to these cameras.

3.3 Traffic Data Use and Sharing

Traffic data will be exchanged between the partner agencies TMSs via the DEN. The exchange of this data will enable coordinated signal timing across jurisdictions. Each partner agency will have a DEN server and a CWD workstation located in their TMC. The DEN server will serve as the interface between different agencies TMSs. The CWD workstation will enable the partner agencies to view each other's traffic data in a common graphical user interface.

3.4 Incident Management

Incident management is an important component of the Silicon Valley ITS West corridor project. A major focus is of this project is to address incidents that occur on I-280 and the resulting traffic that is diverted to arterials in the project area. Using information collected by the CCTV cameras, incidents can be identified in the project area. The partner agencies can use information about the incident to determine what actions need to be taken to respond to and manage an incident, as well as manage the congestion that results from the incident.

Incident management involves interagency coordination such as coordination between Caltrans and the local agencies when incidents on freeways may impact traffic on arterials and vice versa. Incident management also involves coordination between the various local agencies within the SV-ITS program. The SV-ITS West project will allow the Cities and other partner agencies shared access to cameras along Stevens Creek Boulevard, Saratoga Avenue and Wolfe Road. This will improve incident management capabilities and coordination between jurisdictions.

Successful incident management across jurisdictions will only occur if an effective *Incident Management Plan* is first in place. . An *Incident Management Plan* is being developed as part of the SV-ITS West project. This *Incident Management Plan* must be adopted by all participating agencies and should detail the procedures to be performed by each agency when an incident has occurred. The plan outlines the components, resources, and interagency cooperation needed to implement an effective incident management plan for the project corridor. With this plan, partner agencies can respond with appropriate measures such as adjusting signal timing on these corridors

Traffic responsive signal timing is another traffic management technique that can be used during incidents. With traffic responsive control, current volumes are used as inputs and appropriate signal timing plans are selected based on predetermined thresholds or using pattern-matching techniques. If an incident occurs, traffic signal timing is automatically adjusted on the affected corridors. For this project, traffic responsive signal control will be implemented along the Stevens Creek Boulevard in the vicinity of the Westfield Shopping Town and Santana Row development. In addition, responsive signal timing plans will be developed for this area as part of the project.

3.5 TMC Operation

Currently, most of the partner agencies staff their TMCs on an as needed basis. Caltrans and City of San Jose are the only agencies that have full time staff dedicated to their TMC operation. The other local agencies staff their TMC when there is a special need such as to manage an incident. It is not envisioned that the agencies will need to hire additional staff to operate their respective TMC assuming their existing staff is properly trained in TMC responsibilities. Some of the day-to-day tasks that TMC staff will need to be trained on include day-to-day system operations, incident management, routine and emergency maintenance, and software configuration management.

3.6 Maintenance

The SV-ITS West project will have operations and maintenance needs after the project is constructed. It will be important for the partner agencies to ensure that all elements of the SV-ITS West corridor project are functioning properly at all times to ensure effective local and regional traffic management. This will require both preventative and emergency maintenance.

Each agency is responsible for any ongoing operating and maintenance cost for all project elements installed in their jurisdiction. Typical maintenance activities include routine checks to ensure proper operation of all equipment, annual cleaning of the CCTV camera lenses and enclosure windows, annually recharging the enclosure pressure of the dome cameras and responding to fiber breaks. The detailed responsibilities and related cost sharing should be outlined in an O&M agreement.

Each partner agency intends to use, operate, and maintain the infrastructure investment made in their jurisdiction according to the goals and objectives of the SV-ITS Program. If a partner agency wishes to use infrastructure installed by the project in a manner that differs from the goals and objectives of the SV-ITS Program, approval from the

Program's Steering Committee will be required. Infrastructure installed by the project is ultimately owned by the SV-ITS Program and its partners.

Agencies should consider including an ongoing maintenance budget item as part of their annual operating budget. An analysis will be performed as part of this project to determine the most cost-effective means to address maintenance of the system. At a minimum, the factors to be addressed will include initial procurement and start-up costs, estimated annual preventive maintenance costs, and estimated annual response maintenance costs.

The burden of the partner agencies assuming the role of maintaining the system may make it more cost effective to contract these services initially and develop a schedule to gradually assume a greater maintenance role as staff can be added and or trained to effectively perform these services. Staffing and training for equipment maintenance is discussed in greater detail below.

Qualified and experienced staff are required for both operating and managing the system. Without increased staffing for operations, it will be difficult to successfully implement the SV-ITS West project. The installation of new technology such as CCTV cameras and fiber will increase the knowledge requirements and burden on existing staff within the partner agencies. The agencies have the option to either outsource the operations and maintenance of the system to a private company or have their staff trained to perform these duties. If the agencies choose the latter alternative, training requirements should be included in the contract specifications.

There are several options available to address maintenance of field devices. The preferred option is highly dependent on the availability of resources that can be committed by the partner agencies. If the agencies have the available maintenance resources but they are in need of training before assuming the role of system maintenance, the contractor to be awarded the system deployment contract can be required to provide operational support and training to agency personnel for a specified period of time. At the end of the operational support period, the partner agencies would assume full responsibility for the maintenance of system. If agencies do not possess the necessary resources and are not in a position to commit to long term maintenance of the corridors, contracting of maintenance operations is a viable option.

3.7 Institutional Agreements

Formal agreements or memoranda of understanding (MOUs) are sometimes required to create an institutional framework for multi-jurisdictional coordination of traffic operations, including incident response. ITS projects, in many cases, are multi-jurisdictional and require new procedures to address coordinated ongoing operation and maintenance of equipment and facilities.

The SV-ITS partnership has put together a MOU that establishes a commitment for the partnering agencies to maintain and operate ITS facilities in a co-operative manner. The agreement also involves the creation of consensus-building groups, such as Technical Advisory Committees and Policy Advisory Committees that can meet to discuss policies and procedures.

In addition to the MOU, a formal Operations and Maintenance Agreement needs to be developed for the SV-ITS West project. This agreement, which would build on the existing MOU framework, will outline the roles and responsibilities of each agency and related policies with regard to operating and maintaining the system after it has been deployed. Some of the topics addressed in such an agreement may include CCTV control priorities and security, data sharing responsibilities and ensuring a financial commitment from each agency to operate maintain their system in a cooperative manner. This type of an agreement will have fiscal implications on the agencies involved since they will be required to budget accordingly for the costs, staff and training associated with operations and maintenance.

Section 4: Recommendations

4.1 ITS Field Devices

The different types of ITS field devices that will be installed for the SV-ITS West project include CCTV cameras, system detectors and emergency vehicle preemption. Recommendations for the locations and types of these devices are presented below.

4.1.1 Camera Locations and Types

The following table (**Table 4-1**) and map (**Figure 4-1**) show the proposed locations of the CCTV cameras. There are 17 proposed locations for new PTZ cameras and three locations where existing video detection will be used for monitoring. There is also an existing Caltrans PTZ camera at Stevens Creek Boulevard & southbound SR 85 that will be tied into the SV-ITS West project.

Table 4-1: CCTV Camera Locations and Types

Location	Owning Agency					
	Caltrans	City of Cupertino	City of San Jose	City of Santa Clara	Santa Clara County	City of Campbell
Stevens Creek Blvd & SR 85 (S)* (existing)	PTZ					
Stevens Creek Blvd & SR 85 (N)*		PTZ				
Stevens Creek Blvd & Stelling Road		PTZ				
Stevens Creek Blvd & Blaney Ave		PTZ				
Stevens Creek Blvd & Wolfe Road		PTZ				
Wolfe Road & Homestead Rd		PTZ				
Wolfe Road & I-280 (N)*		PTZ				
Wolfe Road & I-280 (S)*		PTZ				
Stevens Creek & I-280*				PTZ		
Stevens Creek & Woodhams				PTZ		
Stevens Creek & Saratoga			PTZ			
Saratoga & I-280 (N)*			PTZ			
Saratoga & I-280 (S)*			PTZ			
Saratoga & San Tomas Expressway					PTZ	
Stevens Creek & Winchester			PTZ			
Stevens Creek & Monroe			PTZ			
Stevens Creek & I-880*			PTZ			
Stevens Creek & MacArthur			PTZ			
Winchester & Campbell						VID

Hamilton & Winchester						VID
Hamilton & Central						VID

* Caltrans right-of-way
PTZ Pan/tilt/zoom camera to be installed
VID Existing video detection cameras to be linked to City's TMC via fiber

In addition to the new PTZ locations listed in Table 4-1, two PTZ cameras will be installed at Stevens Creek and De Anza Boulevard as part of the De Anza Boulevard ATMS project and one PTZ camera will be installed at Stevens Creek Boulevard and Lawrence Expressway as part of the Lawrence Expressway TOS project. The locations of the De Anza Boulevard, Lawrence Expressway and Caltrans cameras are shown in **Figure 4-1** along with the locations of other existing and proposed ITS cameras within the project area.

Based on preliminary field design, it is recommended that all new camera installations be equipped with PTZ capabilities. All new PTZ cameras will be installed on existing poles except for the locations in Caltrans right of way, where the cameras will be mounted on new poles. It is also recommended that dome mounted PTZ cameras be used to maintain consistency with other projects and minimize spare inventory requirements.

As indicated in **Table 4-1**, there are three intersections in the City of Campbell with existing VID cameras that will be used for surveillance. As part of this project, video from these cameras (installed on traffic signal mast arms) will be fed back to Campbell's TMC on fiber. It should be noted that these VID cameras are fixed and are not set to provide distant viewing capabilities since their primary function is traffic detection. Upgrading the VIDs will provide added surveillance capability, but not optimum viewing capabilities.

Due to budget constraints, not all of these cameras will be installed on this project. Several locations will become Add Alternates and may be installed on this project or postponed for a future project.

Figure 4-1: Map of SV-ITS West Camera Locations

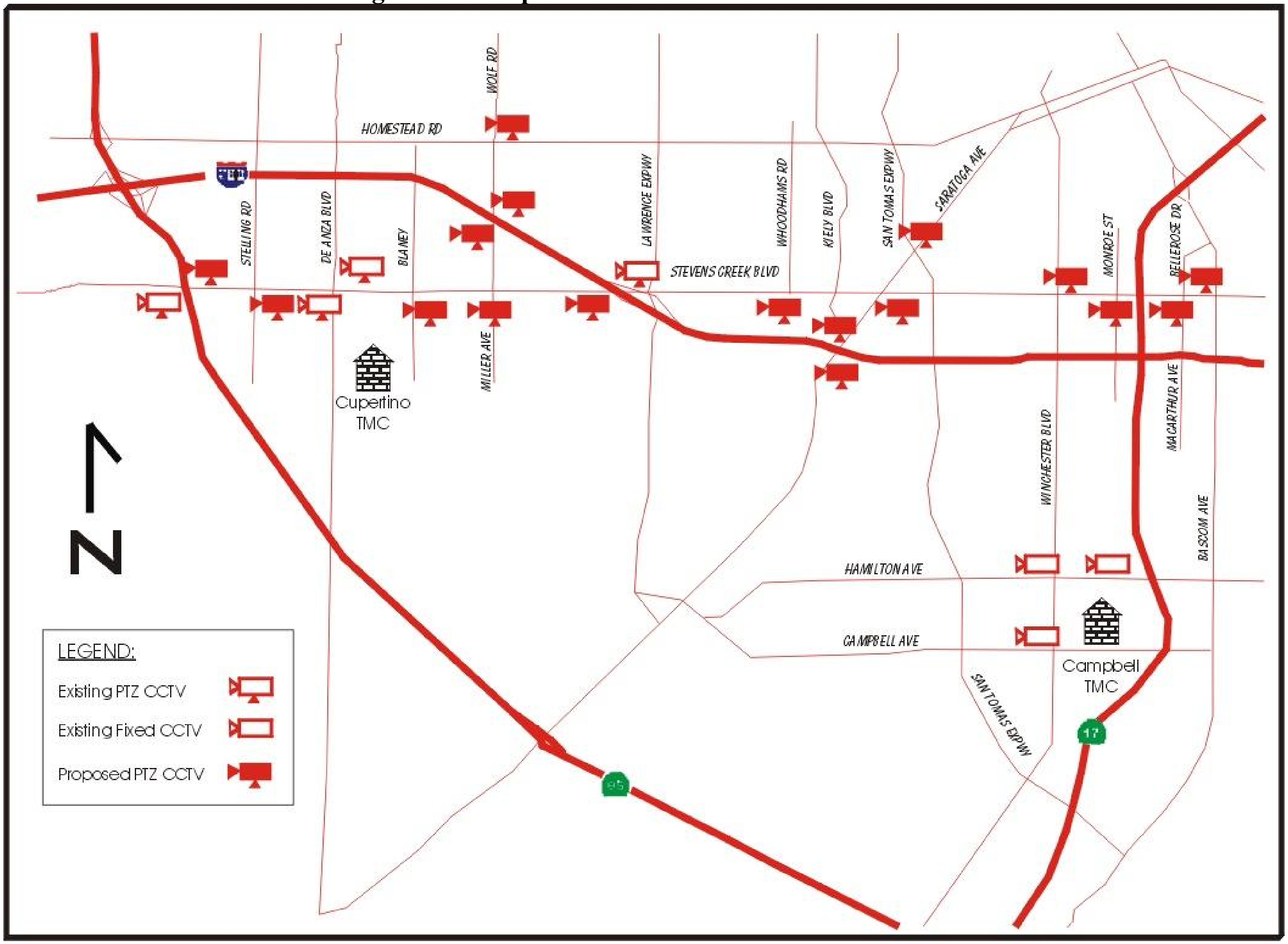
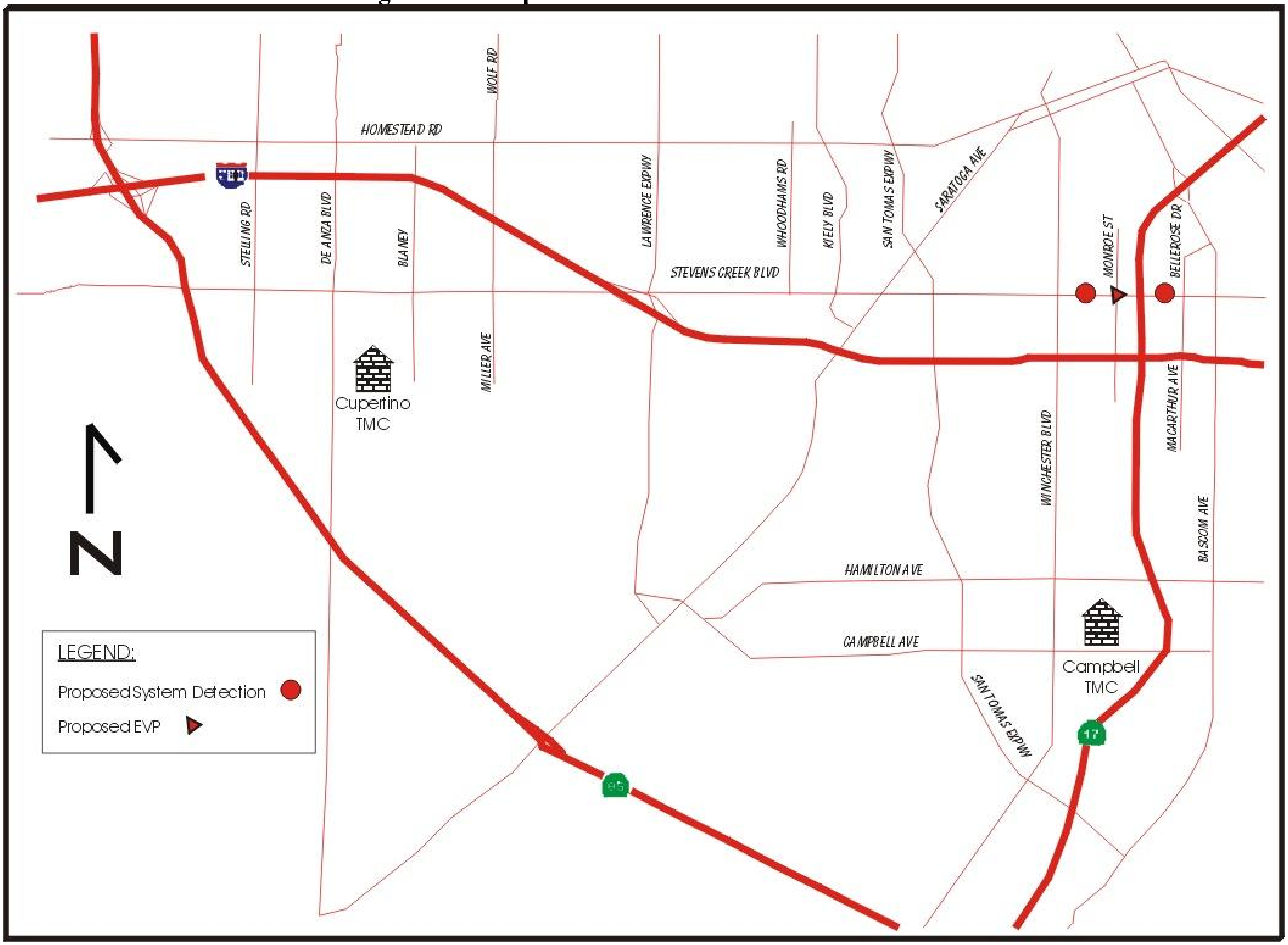


Figure 4-2: Map of SV-ITS West Detector Locations



4.1.2 Vehicle Detection Location and Types

It is recommended that inductive loops be installed at mid-block locations on Stevens Creek Boulevard to serve as system detectors for the SV-ITS West project. Inductive loops are recommended for vehicle detection for this project since they are a proven technology and they are consistent with existing vehicle detection technologies being used by partner agencies in the project area.

Two locations on Stevens Creek Boulevard between Bascom Avenue and Winchester Avenue will have system detectors installed to feed real-time counts to the San Jose TMC. The loops will be installed in both the eastbound and westbound lanes at both locations (see **Figure 4-2**). These locations were selected to fill in gaps in the existing loop detector coverage in the area of concern.

Traffic responsive signal timing patterns will be implemented as part of this project for the traffic signals on Stevens Creek Boulevard near the entrance to Santana Row and Westfield Shopping Center to help with the highly variable traffic volumes entering and exiting those sites. The traffic responsive timing patterns will change based on the data received from the new system detectors and existing loop detectors installed in the area.

4.1.3 Emergency Vehicle Preemption

In the City of San Jose, an emergency vehicle preemption device will be installed at the intersection of Stevens Creek Boulevard and Monroe Avenue (see **Figure 4-2**) due to a fire station located south of the intersection. The device at this location will facilitate safe emergency egress for fire personnel from the fire station and improve safety and emergency response time of emergency vehicles.

4.2 Communications

SV-ITS partners agreed that single mode fiber be installed for the SV-ITS West project. Fiber will be used for both C2F and C2C communications. The following discussion provides a general concept of communications for the SV-ITS West project. A more detailed discussion is provided in the *Design Requirements Report.*

4.2.1 Center-to-Field Communications

For PTZ cameras, it is recommended that video be brought directly from the field devices to the Cupertino TMC by using point-to-point video optical transceivers (VOTR) on individual dedicated fibers. The three camera locations in the City of Campbell will be linked to the City of Campbell TMC. The other 20 camera locations will be linked directly from the field to the Cupertino TMC since there are more available fibers along that path. The City of San Jose will have access to these 20 cameras through a C2C communications link with the Cupertino TMC.

Where multiple fixed video detection cameras are installed, video multiplexers will be used to combine multiple camera video feeds onto a single fiber for transmission to the TMC. At the TMC demultiplexers will separate the individual camera feeds for input into the video matrix. The video multiplexers and demultiplexers take the place of the VOTR pairs used for the PTZ installations.

For the system detectors, data will be brought from the loops to the upstream controller cabinet where the data will then be transmitted to the San Jose TMC using optical transceivers and fiber optics. In other words, the San Jose central traffic signal system will be used to collect system detector data. Once that data is in the central signal system, it can then be distributed to other agencies' systems via the DEN.

4.2.2 Center-to-Center Communications

For communications between the Cupertino TMC and the San Jose TMC, a combination of existing SV-ITS fiber and new fiber will be used. Six fibers will be required for the transmission of data and video signals between these two TMCs. Two of these fibers will be used to connect Ethernet switches located in each TMC. This Ethernet link will enable the DEN servers to be networked. Two fibers will be used to exchange video and CCTV control data between the TMCs. The other two fibers will be used to provide redundant video tie lines between the TMCs along a different fiber path.

In addition, two fibers will be used for a C2C link between Cupertino TMC and Campbell TMC. These fibers will be used for a DEN Ethernet link. Two fibers from the Stevens Creek trunk cable will be spliced to the SV-ITS existing fiber cable along San Tomas Expressway which connects to the Campbell TMC. This interface is described in more detail in the next section.

Also, two fibers will be reserved for future C2C connections between City of Sunnyvale and City of San Jose, and City of Sunnyvale and City of Cupertino. The C2C connections will be used for DEN links. The reserved fiber, which terminates at the intersection of De Anza Boulevard and Homestead Road, will be extended to the Sunnyvale TMC as part of a future project.

The proposed fiber trunk along Stevens Creek Boulevard has been sized at 144 fibers from SR 85 to Lawrence Expressway through an agreement with Santa Clara County. Of these 144 fibers, 96 will be allocated to the SV-ITS network and 48 will be provided to Santa Clara County. The 48 fibers used by the County will be spliced to existing County fiber at Lawrence Expressway and Stevens Creek. From Lawrence Expressway to Bascom, a 96-fiber cable we be installed along Stevens Creek to serve as the SV-ITS trunk. The 96 fibers allocated to SV-ITS is consistent with planned fiber on De Anza Boulevard and other recent projects in the SV-ITS network.

Of the 96 fibers along Steven Creek Boulevard allocated to the SV-ITS West project,

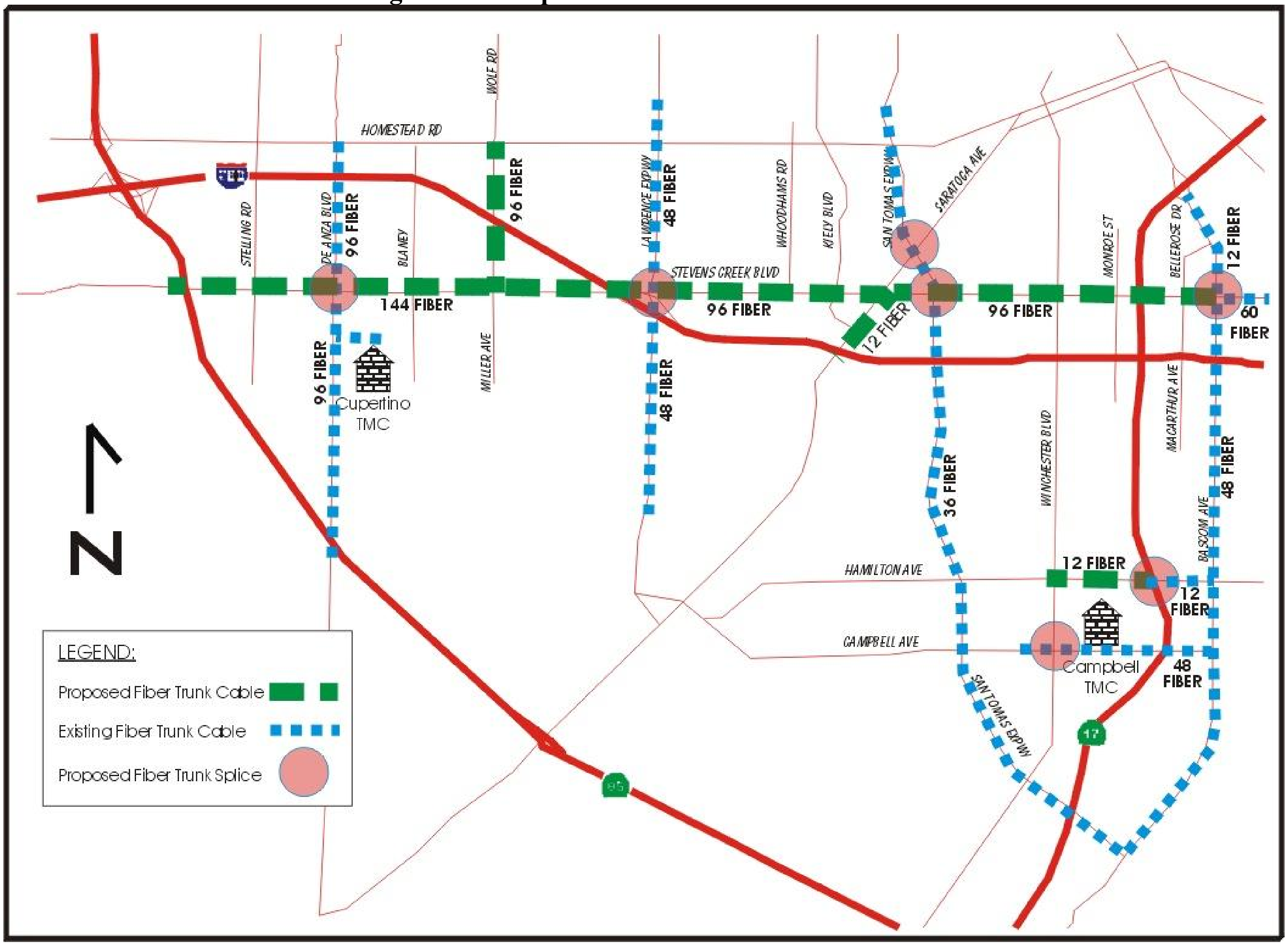
- 18 will be used for linking the proposed field devices to Cupertino TMC;
- 4 will be used as video tie lines between Cupertino TMC and San Jose TMC;
- 2 will be used as DEN tie lines between Cupertino TMC and San Jose TMC;
- 2 will be used as DEN tie lines between Cupertino TMC and Campbell TMC; and
- 2 will be used as future DEN tie lines between Sunnyvale TMC and San Jose TMC.

The 96-fiber count should be more than sufficient to accommodate this project and the addition of future field devices and future SV-ITS extensions.

4.2.3 Proposed Fiber Optics Routes

Due to the long and narrow geographical layout of the field devices within the project corridor, the proposed layout of the fiber optic network was selected as a "trunk and branch" topology. Those devices not located along the main communications trunk between the Cupertino and San Jose TMCs will be serviced by branches off this trunk along the arterial streets. See **Figure 4-3**.

Figure 4-3: Map of SV-ITS West Fiber Network



5. Estimate of Probable Costs and Conclusion

5.1 Construction Costs

The total budget for the construction of the SV-ITS West project is approximately $1,600,000. This includes the costs of the ITS field devices, TMC upgrades, communications equipment, and installation of the system. A breakdown of the estimated construction costs for this cable project are provided below.

Table 5-1 shows the estimated construction costs using SMFO cable as the communications medium. These costs assume that some of the SMFO cable will be installed in the existing signal interconnect conduit along Stevens Creek Boulevard. New conduit will be installed along Stevens Creek Boulevard where no signal interconnect conduit exists or the existing conduit is unusable.

Preliminary field work indicates that much of the existing signal interconnect conduit on Stevens Creek Boulevard is two inch galvanized steel except in Caltrans right of way where two inch PVC conduit is used. The existing galvanized steel conduit shows some signs of corrosion but appears to be reusable in many locations in the City of Cupertino. It is recommended that the steel conduit be cleaned prior to fiber installation. The existing PVC conduit is in good condition. In some areas on Stevens Creek Boulevard the existing interconnect conduit is 1.5-inch galvanized steel which is too small to fit both SIC and a 96 strand fiber cable. The City of Cupertino has given permission to remove and dispose their existing SIC, which will allow enough room for fiber to be installed in 1.5-inch conduit.

Table 5-1 represents a preliminary estimate for the total construction cost of the system including installation. Although this currently exceeds the project budget, several elements will be staged or omitted in order to meet budget restrictions. The project partners have met to prioritize different elements of the project. Those elements that are lowest on the priority list will be treated as add alternates in the Contractor bid list.

Table 5-1: Silicon Valley ITS West Estimate of Probable Construction Costs

Item No.	Item Description	Approx Qty.	Unit	Unit Price	Total
1	Traffic Control	1	LS	$35,000	$35,000
2	Mobilization	1	LS	$25,000	$25,000
3	Furnish and Install Color Camera Assembly (PTZ - Dome on existing pole)	10	EA	$14,000	$140,000
4	Furnish and Install Color Camera Assembly (PTZ - Pole Top on new pole)	7	EA	$14,000	$98,000
5	Furnish and Install CCTV Cables	1	LS	$10,000	$10,000
6	Remove and Replace Existing Pan-Tilt Motor	1	LS	$500	$500
7	Furnish and Install 12.19m CCTV Pole with Foundation	7	EA	$15,000	$105,000
8	Furnish and Install Emergency Vehicle Preemption Detector	3	EA	$1,500	$4,500
9	Furnish and Install Emergency Vehicle	3	EA	$500	$1,500

	Preemption Discriminator Unit, Connectors, and other appurtenances				
10	Furnish and Install Emergency Vehicle Preemption System Chassis	1	EA	$1,200	$1,200
11	Green Sense Harness	1	EA	$600	$600
12	Furnish and Install Loop Detector Cable (DLC)	1,830	M	$4.00	$7,320
13	Furnish and Install No. 2 Service Conductor	1,590	M	$5.00	$7,950
14	Furnish and Install No. 6 Service Conductor	90	M	$4.00	$360
15	Install Agency-Furnished 144 Strand SMFO Cable in empty conduit	2,380	M	$6.75	$16,065
16	Install Agency-Furnished 144 Strand SMFO Cable in occupied conduit	2,720	M	$14.80	$40,256
17	Furnish and Install 96 Strand SMFO Cable in empty conduit	5,840	M	$13.00	$75,920
18	Furnish and Install 96 Strand SMFO Cable in occupied conduit	2,140	M	$18.00	$38,520
19	Furnish and Install 48 Strand SMFO Cable in empty conduit	40	M	$10.00	$400
20	Furnish and Install 48 Strand SMFO Cable in occupied conduit	110	M	$15.00	$1,650
21	Furnish and Install 12 Strand SMFO Cable (Trunk) in empty conduit	1,760	M	$8.00	$14,080
22	Furnish and Install 12 Strand SMFO Cable (Branch w/Connectors) in empty conduit	360	M	$10.00	$3,600
23	Furnish and Install 12 Strand SMFO Cable (Branch w/Connectors) in occupied conduit	190	M	$15.00	$2,850
24	Furnish and Install 12 Strand SMFO Cable (Branch w/Connectors) in Pull Box (coiled for future)	240	M	$8.00	$1,920
25	Install Agency Furnished 25-Pair TWP Signal Interconnect Cable	1,190	M	$4.00	$4,760
26	Furnish and Install 53mm GRS & 76mm PVC Conduit by Rock-Wheeling	1,190	M	$97.00	$115,430
27	Furnish and Install 53mm PVC & 76mm PVC Conduit by Directional Drilling	360	M	$95.00	$34,200
28	Furnish and Install 53mm Conduit by Trenching	20	M	$72.00	$1,440
29	Furnish and Install 53mm Conduit by Directional Drill	260	M	$83.00	$21,580
30	Furnish and Install 76mm Conduit by Trenching	1,740	M	$83.00	$144,420
31	Furnish and Install 76mm Conduit by Directional Drill	7,590	M	$85.00	$645,150
32	Furnish and Install 76mm GRS Conduit to bridge structure	160	M	$50	$8,000
33	Furnish and Install No. 5 Pull Box	4	EA	$500	$2,000
34	Furnish and Install No. 6 Pull Box	196	EA	$700	$137,200
35	Remove Existing Pull Box	24	EA	$500	$12,000
36	Furnish and Install 1.8m x 1.8m Loop Detector	11	EA	$350	$3,850
37	Furnish and Install Detector Handholes	4	EA	$250	$1,000
38	Furnish and Install 2-Channel Detector Card	6	EA	$250	$1,500
39	Furnish and Install F/O Splice Pull Box	40	EA	$1,000	$40,000
40	Furnish and Install Underground Splice Closure	20	EA	$1,500	$30,000

41	Splice and Test Fiber	1	LS	$25,000	$25,000
42	Furnish and Install Video Optical Transceiver (VOTR) (pair)	17	EA	$5,500	$93,500
43	Furnish and Install 4-Channel Multiplexer (pair)	3	EA	$4,500	$13,500
44	Furnish and Install 4-Channel Mux/Demux with Data Port (pair)	1	EA	$7,000	$7,000
45	Install Agency-Furnished 4-Channel Mux/Demux (pair)	1	EA	$300	$300
46	Furnish and Install Type 334 Cabinet and Foundation	7	EA	$6,500	$45,500
47	Furnish and Install Type III-AF Service Enclosure and Foundation	7	EA	$3,000	$21,000
48	Furnish and Install DEN Server	1	LS	$4,000	$4,000
49	Furnish and Install DEN Workstation	1	LS	$3,000	$3,000
50	Furnish and Install Fast Ethernet Optical Transceiver	4	EA	$1,000	$4,000
51	Furnish and Install Code Distribution Unit	1	EA	$1,500	$1,500
52	Furnish Video Optical Transceiver (VOTR) (spare)	4	EA	$2,500	$10,000
53	Furnish and Install Video Encoder Assembly	8	EA	$4,500	$36,000
54	Furnish and Install Optical Transceivers	9	EA	$1,500	$13,500
		Sub-total			$2,112,521
		10% Bidding Contingency			$211,252
		Sub-total			$2,323,773
		10% Supplemental Work			$232,377
		TOTAL			$2,556,150
		Total Requested by Others			$108,218
		Total Less Other Agencies			$2,447,932

5.2 Operations and Maintenance Costs

Other costs to be considered that are not listed in **Table 5-1** are operations and maintenance costs and training. Operations and maintenance (O&M) costs will have to be funded using the partner agencies' operations and maintenance budget. One option for obtaining additional funding for O&M would be for the SV-ITS Program to apply for a special O&M grant from either the State or the federal government.

Training on operations and maintenance of the system will be provided to each of the agencies. Operations duties include control and monitoring of CCTV cameras and the agency's respective TMS, making adjustments to signal timing as necessary and implementing a multi-jurisdictionsal incident management program. Most agencies' staff are already familiar with operating their current TMS so there shouldn't be any additional cost associated with operating their TMS. Training will be required to teach staff how to control and display CCTV cameras and how to implement incident management procedures.

Maintenance duties will include fiber maintenance (i.e., responding to breaks) and routine maintenance of field devices such as camera cleaning and replacing equipment such as loops and VOTRs if they fail. Of these, fiber maintenance is the most complicated and requires the most training.

The partner agencies basically have two alternatives for maintaining the SV-ITS West project after it is constructed. They can either maintain it themselves or have the maintenance duties outsourced. The expected maintenance costs for the two maintenance alternatives are provided below.

Alternative 1: Partner Agencies perform maintenance

First, if the agencies maintain the entire system (including fiber), they will need to purchase the following equipment (as a minimum) for fiber maintenance:

- OTDR (~$18,000),
- Portable V-groove fusion splicer (~$15,000),
- Fiber cleaver, CT-04 or CT-07 (~$2,000), and
- Power meter (~$5,000).

Thus, the total cost for the fiber maintenance equipment will be approximately $40,000.

The agencies will also need to pay for training for fiber maintenance and routine system maintenance as well as training to operate the system. If the agencies maintain the entire system, training is estimated to be around $20,000 per year for four people.

In addition, there will be recurring costs associated with replacement and maintenance of system components other than fiber. It is estimated that the agencies will need to replace the following components every five years:

- 2 color camera assemblies ($10,000),
- 3 VOTRs ($7,500), and
- 2 monitors ($2,500).

Thus, the estimated total recurring cost for replacing equipment will be approximately $20,000 every five years. This equates to an annualized cost (not adjusted for inflation) of $4,000.

In order to be prepared for replacement of system components, it is recommended that the agencies maintain an adequate inventory of spare parts and components. At the minimum, each agency should have the following components in stock:

- 2 color camera assemblies ($10,000),
- 4 VOTRs ($10,000), and
- 10 connectorized 12-fiber patch cords ($2,000).

The initial cost for the spare parts inventory is approximately $22,000 and the inventory will need to be restocked as items are replaced. This equipment could be procured as part of the construction contract, if there is adequate budget.

It is not envisioned that the partner agencies will need to hire any additional staff for operations and maintenance of additional equipment installed as part of the Silicon Valley ITS West project.

Alternative 2: Maintenance Contractor

Another option for the SV-ITS partnership is to use an emergency contractor to perform fusion splicing to repair fiber breaks. Fusion splicing is the most complicated of the fiber maintenance tasks. If this option were chosen, the agencies would not need to purchase the OTDR, fusion splicer or cleaver. The agencies would still need the power meter for testing. The cost of an emergency contractor is estimated to be $6,000 annually assuming there are two eight-hour service calls per year, but there is a savings of about $35,000 on maintenance equipment.

Aside from emergency maintenance, there will also be routine maintenance such as camera cleaning and replacement of failed parts. These duties could also be contracted out on a year by year basis.

Even if the partner agencies decide to contract out the maintenance of their fiber and field devices, their staff will still need to receive some basic training for the operations and maintenance of the SV-ITS West system. This training can be written into the construction contract and is estimated to be approximately $10,000 per year for annual training for four people. The cost for this training is estimated lower than the training in Alternative 1 because it will not include training for fiber maintenance.

In addition, there will be recurring costs associated with replacement and maintenance of system components other than fiber. It is estimated that the City will need to replace the following numbers of components every five years:

- 2 color camera assemblies ($10,000),
- 3 VOTRs ($7,500), and
- 2 monitors ($2,500).

Thus, the estimated total recurring cost for replacing equipment will be approximately $20,000 every five years. This equates to an annualized cost (not adjusted for inflation) of $4,000.

In order to be prepared for replacement of system components, it is recommended that the agencies maintain an adequate inventory of spare parts and components. At the minimum, each agency should have the following components in stock:

- 2 color camera assemblies ($10,000),
- 4 VOTRs ($10,000), and
- 10 connectorized 12-fiber patch cords ($2,000).

The initial cost for the spare parts inventory is approximately $22,000 and the inventory will need to be restocked as items are replaced. This equipment could be procured as part of the construction contract, if there is adequate budget.

It is not envisioned that the partner agencies will need to hire any additional staff for operations and maintenance of additional equipment installed as part of the Silicon Valley ITS West project.

Spare equipment will be held at the City of San Jose if any is ordered as part of the Silicon Valley ITS West project.

5.3 Funding

Expanding the SV-ITS West project, such as adding additional ITS field devices or extending the fiber optics communications infrastructure, will require the partner agencies to identify additional sources of funding. Additional funding will also be required for operations and maintenance of the SV-ITS West system throughout its lifecycle if partner agencies do not have adequate resources in their current O&M budget.

As mentioned above, one option for partner agencies to obtain additional funding for system expansion and O&M would be for the SV-ITS Program to apply for a special grants from either the State or the federal government. Examples of these grants include ITS Deployment earmarks and congestion mitigation air quality (CMAQ) funding. Another alternative is for San Jose and other partner agencies to obtain financial and technical resources by partnering with private sector telecommunications and technology companies to help deploy additional fiber, technologies, and other assistance.

6. SV-ITS West Project Architecture

This section defines the ITS architecture developed for the SV-ITS West project. The purpose of developing an ITS architecture for the project is to ensure the following: 1) compatibility between arterial operations subsystems, 2) compliance with national ITS standards and 3) sharing of data between project partners and other institutions involved in arterial operations such as Metropolitan Transportation Commission (MTC) and local fire departments. The ITS architecture is a high level depiction of how system components fit together and interact with each other to make the system work. By defining the connections between subsystems, the architecture identifies where standards may be needed. Also, the architecture development process helps identify additional opportunities for integration that may not have been previously considered.

6.1 Background

In June of 1996, the Federal Highway Administration (FHWA) and Joint Program Office (JPO) completed the development of the National ITS Architecture. It defines the framework around which different design approaches can be developed while maintaining the benefits of a common architecture. The National ITS Architecture provides a standard vocabulary, a description of options to consider for local and regional ITS functions and activities, and a general set of tools to assist with systems integration. In addition, it identifies and specifies the requirements for the standards needed to support national and regional interoperability, as well as product standards needed to support economy of scale considerations in deployment.

The National ITS Architecture is essentially a tool to assist in the development of specific architectures. The use of the National ITS Architecture reduces the time and costs required to develop architectures by providing a framework and process to follow. It allows for developing architectures in which future expansion, information exchange, and integration of systems (both existing and future) are inherent.

Turbo Architecture, Version 2.0, was utilized to develop this architecture. Turbo Architecture is a "high level, interactive software program that aids transportation planners and system integrators, both in the public and private sectors, in the development of a Regional and/or Project Architecture."[1] The resulting architecture is in a Microsoft Access database-compatible file that can be easily utilized in the future to further enhance and modify this first version.

6.1.1 Relationship with MTC Bay Area Architecture

The SV-ITS project architecture presented here was developed from scratch specifically for the SV-ITS West project. Every attempt was made to maintain consistency with the Bay Area Regional ITS Architecture being developed by MTC. The SV-ITS project architecture has been tailored to meet the specific interests of the project stakeholders and is not intended to cover all aspects of ITS deployment in the Bay Area. However, the architecture should not conflict in any way with the Bay Area Regional ITS Architecture.

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[1] Turbo Architecture, version 2.0, USDOT, 2002.

6.1.2 Definition of Project Architecture

The project architecture describes how system components fit together and interact with each other to make the system work. It defines the functions that will be performed by the system, the physical subsystems, where those functions reside, the interfaces and information flows between the subsystems, and the communications requirements for the information flows.

An ITS architecture is not a design. Several different system designs or implementations can fit within the same architecture. An ITS architecture defines the framework and functionality, while a design defines the specific plans for implementation. The specific system design for the SV-ITS West project is addressed in the *Detailed Design Report*.

6.2 SV-ITS West Project Architecture Elements

The project architecture presented here represents the architecture for the SV-ITS West project. The intent of this architecture is to focus on elements that were deemed critical to the project. The SV-ITS West Architecture includes major arterial operations systems, freeway operations systems, information service providers (ISPs), and other systems that the SV-ITS West project will interface with such as the SV-ITS DEN, MTC TravInfo and Caltrans TMC. However, not every subsystem or function relating to ITS deployment in the South Bay was included in the architecture. For instance, ITS for transit operations were not covered in the architecture since they were not a part of the project scope. These systems would be part of a regional ITS architecture, which has a broader focus.

The following information is preliminary output from the SV-ITS West project architecture. The output, which was produced by the Turbo Architecture software, includes: 1) project inventory, 2) market package inventory, 3) sausage diagram, and 4) interconnect diagram.

6.2.1 Project Inventory

The first step to developing the project architecture using the Turbo Architecture software was to input the inventory. The inventory consists of the physical entities, including agencies, vehicles, systems and field elements that are involved in the SV-ITS West project. The inventory includes both existing and planned components.

The elements that were identified as part of the SV-ITS West project are identified in **Appendix 1**. There are a total of 29 elements identified in the SV-ITS West architecture inventory. In **Appendix 1**, all of the elements are listed along with their status, associated stakeholder and the generic entity within the National Architecture to which they are mapped. In some cases, an element is mapped to more than one entity indicating the element performs a number of functions.

The entities defined in the National Architecture include 21 subsystems, which are grouped into four classes: Centers, Roadside, Vehicles, and Travelers. Example subsystems are the Traffic Management Subsystem, the Vehicle Subsystem, and the Roadway Subsystem. These correspond to existing things in the physical world: respectively traffic operations centers, automobiles, and roadside signal controllers. Due to this close correspondence between the physical world and the subsystems, the subsystem interfaces are prime candidates for standardization. A listing of the 21 subsystems are provided in **Table 6.1**.

Table 6.1: National ITS Architecture Subsystems

Centers	Archived Data Management Subsystem Commercial Vehicle Administration Emergency Management Emissions Management Fleet and Freight Management Information Service Provider Maintenance and Construction Management Toll Administration Traffic Management Transit Management
Roadside	Commercial Vehicle Check Parking Management Roadway Subsystem Toll Collection
Traveler	Personal Information Access Remote Traveler Support
Vehicle	Commercial Vehicle Subsystem Emergency Vehicle Subsystem Maintenance and Construction Vehicle Transit Vehicle Subsystem Personal Vehicle

The entities in the National Architecture also include 71 terminators, which define the boundary of the National ITS Architecture. The terminators represent the people, systems, and general environment that interface to ITS. A list of the 71 terminators is provided in **Table 6.2**.

Table 6.2: National ITS Architecture Terminators

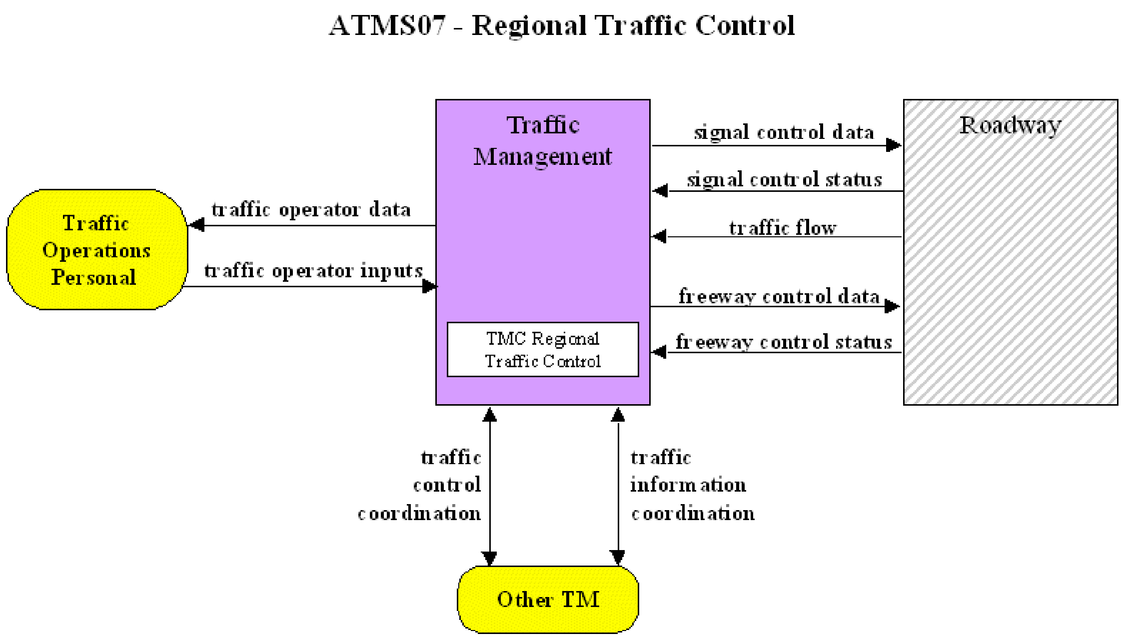
Environment	Environment Potential Obstacles Roadway Environment Secure Area Environment Traffic Vehicle Characteristics
Human	Archived Data Administrator Commercial Vehicle Driver Commercial Vehicle Manager CVO Inspector Driver Emergency Personnel Emergency System Operator ISP Operator Maintenance and Construction Center Personnel Maintenance and Construction Field Personnel Parking Operator Pedestrians

	Toll Administrator Toll Operator Traffic Operations Personnel Transit Driver Transit Fleet Manager Transit Maintenance Personnel Transit System Operators Transit User Traveler
Other System	Other Archives Other CVAS Other EM Other ISP Other MCM Other MCV Other Parking Other Roadway Other TM Other Toll Administration Other TRM Other Vehicle
System	Archived Data User Systems Asset Management Basic Commercial Vehicle Basic Maintenance and Construction Vehicle Basic Transit Vehicle Basic Vehicle Care Facility CVO Information Requestor DMV Emergency Telecommunications System Enforcement Agency Equipment Repair Facilities Event Promoters Financial Institution Government Reporting Systems Intermodal Freight Depot Intermodal Freight Shipper Location Data Source Maintenance and Construction Administrative Map Update Provider Media Multimodal Crossings Multimodal Transportation Service Provider Other Data Sources Rail Operations Storage Facility Surface Transportation Weather Service Trade Regulatory Agencies Traveler Card Wayside Equipment Weather Service Yellow Pages Service Providers

6.2.2 Market Packages

One of the functions of the National ITS Architecture documentation is to provide a common vocabulary for the development of individual system architectures around the nation. The basic building block of this architecture is the *market package*. A market package is a group of technologies and data flows based on functionality. Each market package represents a function that can be deployed as an integrated capability. Many market packages can be deployed incrementally so advanced packages can be efficiently implemented based on earlier deployments. **Figure 6.1** depicts an example of one market package, Regional Traffic Control. Notice that the market package includes subsystems (Traffic Management and Roadway) and terminators (Other TM and Traffic Operation Personnel) and the data flows between them.

Figure 6.1: Regional Traffic Control Market Package



The market package selection process is typically performed after an inventory has been created. National ITS Architecture Version 4.0 includes 75 Market Packages, which are listed in **Table 6.3**. From this list, 11 relevant market packages were selected as being relevant to the project. The 11 market packages that were selected to serve as the basis for the SV-ITS West project are listed in **Appendix 2**.

Table 6.3: National ITS Architecture Market Packages

Market Package	Market Package Name
ad1	ITS Data Mart
ad2	ITS Data Warehouse
ad3	ITS Virtual Data Warehouse
apts1	Transit Vehicle Tracking
apts2	Transit Fixed-Route Operations
apts3	Demand Response Transit Operations
apts4	Transit Passenger and Fare Management
apts5	Transit Security
apts6	Transit Maintenance
apts7	Multi-modal Coordination
apts8	Transit Traveler Information
atis1	Broadcast Traveler Information
atis2	Interactive Traveler Information
atis3	Autonomous Route Guidance
atis4	Dynamic Route Guidance
atis5	ISP Based Route Guidance
atis6	Integrated Transportation Management/Route Guidance
atis7	Yellow Pages and Reservation
atis8	Dynamic Ridesharing
atis9	In Vehicle Signing
atms01	Network Surveillance
atms02	Probe Surveillance
atms03	Surface Street Control
atms04	Freeway Control
atms05	HOV Lane Management
atms06	Traffic Information Dissemination
atms07	Regional Traffic Control
atms08	Incident Management System
atms09	Traffic Forecast and Demand Management
atms10	Electronic Toll Collection
atms11	Emissions Monitoring and Management
atms12	Virtual TMC and Smart Probe Data
atms13	Standard Railroad Grade Crossing
atms14	Advanced Railroad Grade Crossing
atms15	Railroad Operations Coordination
atms16	Parking Facility Management
atms17	Regional Parking Management
atms18	Reversible Lane Management
atms19	Speed Monitoring
atms20	Drawbridge Management
avss01	Vehicle Safety Monitoring
avss02	Driver Safety Monitoring
avss03	Longitudinal Safety Warning

avss04	Lateral Safety Warning
avss05	Intersection Safety Warning
avss06	Pre-Crash Restraint Deployment
avss07	Driver Visibility Improvement
avss08	Advanced Vehicle Longitudinal Control
avss09	Advanced Vehicle Lateral Control
avss10	Intersection Collision Avoidance
avss11	Automated Highway System
cvo01	Fleet Administration
cvo02	Freight Administration
cvo03	Electronic Clearance
cvo04	CV Administrative Processes
cvo05	International Border Electronic Clearance
cvo06	Weigh-In-Motion
cvo07	Roadside CVO Safety
cvo08	On-board CVO Safety
cvo09	CVO Fleet Maintenance
cvo10	HAZMAT Management
em1	Emergency Response
em2	Emergency Routing
em3	Mayday Support
em4	Emergency Routing
mco1	Maintenance and Construction Vehicle Tracking
mc02	Maintenance and Construction Vehicle Maintenance
mc03	Road Weather Data Collection
mc04	Weather Information Processing and Distribution
mc05	Roadway Automated Treatment
mc06	Winter Maintenance
mc07	Roadway Maintenance and Construction
mc08	Work Zone Management
mc09	Work Zone Safety Monitoring
mc10	Maintenance and Construction Activity Coordination

Turbo Architecture maps relevant inventory elements to each market package based on the National Architecture model. This was done for the SV-ITS West Architecture as can be seen in **Appendix 2**. The inventory elements were then selected or not selected depending on whether or not they fit into that market package within the context of the SV-ITS West project. Each inventory element must be associated with at least one market package, although an inventory element can also be associated with more than one market package.

6.2.3 Sausage Diagram (Subsystems and Interconnects)

The inventory and market packages envisioned for deployment were used to define the subsystems and interconnects that comprise the top-level physical architecture for the freeway system. All three layers (transportation, communications, and institutional) are inherent in this view of the architecture. The subsystems correspond to the transportation layer. The agencies and other regional components correspond to the institutional layer. The connections joining each subsystem form a top-level version of the communication layer.

Appendix 3 summarizes all three layers into a physical view of the architecture. This depiction is informally known as a sausage diagram. The seven subsystems that were identified as part of the SV-ITS West architecture are shown in the white boxes. These subsystems include Traffic Management, Information Service Provider, Emergency Management, Remote Traveler Support, Personal Information Access, Emergency Vehicle, and Roadway.

6.2.4 Interconnect Diagram

Turbo Architecture maps all of the interconnections identified for SV-ITS West elements. The interconnections establish the relationships between SV-ITS West project elements and identify which elements will exchange data. The interconnections do not establish the direction of data flow, only that there is a connection between two elements. Interconnections are either identified as "existing" or "planned". **Appendix 4** shows all of the interconnections identified in the SV-ITS West architecture. The complete figure can be viewed using Turbo Architecture and the data set.

6.3 Standards

In addition to the SV-ITS West Architecture, an evaluation of applicable standards relevant to the architecture has been conducted. ITS standards define how system components interconnect and work within the overall framework of the National ITS Architecture. Standards allow for different components, technologies, and infrastructure to interact together to support a seamless transportation system. The National ITS Architecture is, essentially, a "standard" framework and foundation for ITS interoperability.

Several national and international standards organizations are working toward developing ITS standards for communications, field infrastructure, messages and data dictionaries, and other areas. The organizations developing standards most applicable to ITS include:

- American Association of State Highway and Transportation Officials (AASHTO);
- American National Standards Institute (ANSI);
- American Society for Testing and Materials (ASTM);
- Institute of Electrical and Electronics Engineers (IEEE);
- Institute of Transportation Engineers (ITE);
- National Electrical Manufacturers Association (NEMA);
- National Transportation Communications for ITS Protocol Joint Committee (NTCIP); and
- Society of Automotive Engineers (SAE).

Within Turbo Architecture, specific national standards developed by these organizations are associated with each data flow. The standards relating to the SV-ITS West architecture have been identified in the ITS standards matrix given in **Table 6.4**. This matrix is a guide to the ITS standards documents that should be considered for use in the Silicon Valley ITS West project.

Each row in the matrix represents an ITS standards document and each column in the matrix represents one of the application areas in the project architecture. The "documents" (the rows) are consensus standards, information reports, and other types of consensus standards documents that specify how different technologies, products, and components interconnect within a consistent framework, which is the National ITS Architecture. The rows are grouped and sorted by document number. The application areas (the columns) are deployment-oriented categories that focus on specific ITS services or systems. Only the application areas that are relevant to the SV-ITS West project are listed in **Table 6.4**. Each application area contains one or more interfaces in the National ITS Architecture.

For each of the application areas, the ITS standards documents that are appropriate for use are identified by a mark in the cell where the row for the standard crosses the column for that application area. Therefore, to use the matrix, choose an application area, scan down that application area column, and observe the marks and the standards that they represent. All of the standards listed in **Table 6.4** are relevant to the SV-ITS West Architecture.

6.4 Summary

These national standards are in various stages of development, testing, and formalization. As appropriate standards are finalized and published, these standards should be incorporated into SV-ITS projects to the extent possible. To be eligible for federal funding for ITS projects, conformance with the National ITS Architecture as well as use of the U.S. Department of Transportation (USDOT) adopted ITS standards (where applicable) are required. The USDOT ITS standards web site (www.ITS-Standards.net) is a good source of current information on the status of each standard and how they can be obtained.

Table 6.4: Relevant ITS Standards

Document Number	Document Name	Center-to-Center				Center-to-Roadside				Roadside-to-Vehicle
		Data Archival	Incident Management	Traffic Management	Traveler Information	Ramp Metering	Traffic Signals	Vehicle Sensors	Video Surveillance	Signal Priority
ASTM	Standard Specification for 5.9 GHz Data Link Layer									●
ASTM	Standard Specification for 5.9 GHz Physical Layer									●
ASTM PS 105-99	Specification for DSRC Data Link Layer									●
ASTM PS 111-98	Specification for DSRC Physical Layer									●
IEEE 1556	Secrecy/Privacy of Vehicle to Roadside Communications									●
ITE TM 1.03	Standard for Functional Level Traffic Management Data Dictionary (TMDD)	●	●	●	●					
ITE TM 2.01	Message Sets for External TMC Communication (MS/ETMCC)	●	●	●	●					
NTCIP 1101	Simple Transportation Management Framework (STMF)					●	●	●	●	
NTCIP 1102	Base Standard: Octet Encoding Rules (OER)	●	●	●	●	●	●	●	●	
NTCIP 1103	Simple Transportation Management Protocol (STMP)					●	●	●	●	
NTCIP 1104	CORBA Naming Convention	●	●	●	●					
NTCIP 1105	CORBA Security Service	●	●	●	●					
NTCIP 1106	CORBA Near-real Time Data Service	●	●	●	●					
NTCIP 1201	Global Object Definitions					●	●	●	●	

NTCIP 1202	Object Definitions for Actuated Traffic Signal Controller Units						●			
NTCIP 1205	Data Dictionary for Closed Circuit Television (CCTV)							●	●	
NTCIP 1208	Object Definitions for Video Switches							●	●	
NTCIP 1209	Transportation System Sensor Objects							●		
NTCIP 1210	Objects for Signal Systems Master						●			
NTCIP 1211	Objects for Signal Control Priority									●
NTCIP 2001	Class B Profile					●	●	●	●	
NTCIP 2101	Point to Multi-Point Protocol Using RS-232 Subnetwork Profile					●	●	●	●	
NTCIP 2102	Subnetwork Profile for PMPP over FSK modems					●	●	●	●	
NTCIP 2103	Subnetwork Profile for Point-to-Point Protocol Using RS 232					●	●	●	●	
NTCIP 2104	Subnetwork Profile for Ethernet	●	●	●	●	●	●	●	●	
NTCIP 2201	Transportation Transport Profile					●	●	●	●	
NTCIP 2202	Internet (TCP/IP and UDP/IP) Transport Profile	●	●	●	●	●	●	●	●	
NTCIP 2301	Application Profile for Simple Transportation Management Framework (STMF)					●	●	●	●	
NTCIP 2302	Application Profile for Trivial File Transfer Protocol							●	●	
NTCIP 2303	Application Profile for File Transfer Protocol	●	●	●	●			●	●	
NTCIP 2304	Application Profile for Data Exchange ASN.1 (DATEX)	●	●	●	●					
NTCIP 2305	Application Profile for Common Object Request Broker Architecture (CORBA)	●	●	●	●					
NTCIP 2501	Information Profile for DATEX	●	●	●	●					
NTCIP 2502	Information Profile for CORBA	●	●	●	●					

7. Conclusion

This *Concept of Operations Report* defined the Silicon Valley ITS West project and identified the technical and institutional actions that should be taken in order to achieve the desired system. In addition, the SV-ITS West project architecture was presented along with relevant National ITS standards. The project architecture that was developed is based on National ITS Architecture.

In general, the Silicon Valley West Corridor project involves the installation of CCTV cameras and inductive loops as detection devices along the principal arterials of Stevens Creek Boulevard, Wolfe Road, Saratoga Avenue and Hamilton Avenue. These ITS elements will be supported by a fiber optics communication system and upgrades to the TMCs in Cupertino, San Jose and Campbell. Partner agencies in this project include Caltrans, Santa Clara County, and the Cities of Cupertino, Santa Clara, San Jose and Campbell.

The purpose of this report was not to document the design of the Silicon Valley ITS West project. Those issues are addressed in the *Design Requirements Report*. The purpose of this report was to address how the system will be operated after it has been deployed. Some of the issues that were discussed in this report included: roles and responsibilities of participating agencies, existing or required agreements for operation of the resulting system, resources needed to operate and maintain the system, location of field devices and coordination with the SV-ITS program partners and related SV-ITS projects to ensure the effectiveness of the regional management plan. With this *Concept of Operations*, the SV-ITS partnership has a common framework for addressing operations and maintenance of the SV-ITS West system.

Appendix 1: Inventory Report

Appendix 2: Market Package Report

Appendix 3: Sausage Diagram

Appendix 4: Interconnect Diagram